FLOWER PHOTOGRAPH.

Illustrating the monochromatic effect of the colours and different shades of green in the plant and flowers of the common thistle.

THE STORY OF PHOTOGRAPHY

BY

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WITH THIRTY-EIGHT ILLUSTRATIONS

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INTRODUCTION.

It is not long since it was common to hear people say of Photography, "O there is nothing in it! It has gone as far as it can go." This was of course the popular verdict; but there were practical men too who were of opinion that little more was to be expected from it. It would be hard to find the man who would say as much to-day. So many advances has Photography made of late—so important has it become as an aid to general science—that it is not easy to over-estimate its claims on the attention of investigators, or to say in what direction its next conquests may not be achieved.

For Photography, as its name implies (*photo*, light, and *grapho*, I trace), is bound up with the theory of light, and hence with solar physics; with spectrum analysis; with chemistry; with optics; and, as we have recently seen in the discovery of the X-rays, with electricity. As to its practical application—that is well-nigh without limit, extending from the record of the lineaments of a criminal to the delineation of the star-lit depths of space. To describe its achievements in the department of industry alone would take volumes, while its relation to painting, design, and illustration constitutes one of the most important

chapters in the development of the fine arts. Indeed, without resorting to the language of exaggeration, it may be said that, both for pleasure and profit, Photography presents one of the most interesting subjects for study that any one can take up.

It is with a view to introduce the subject in this light that the following pages have been written—not so much with the object of producing a manual to teach Photography as an art; but, while giving due weight to that side of the subject, to present it in its more scientific aspects.

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THE STORY OF PHOTOGRAPHY.

CHAPTER I.

FIRST STEPS TOWARDS PHOTOGRAPHY.

THE history of photography is a curious one. It shows how important discoveries are the outcome, not of one mind, but of the investigations of numberless men, working entirely independently of each other, and to ends altogether diverse. It falls to one man perhaps, by a lucky hit, to put the finishing touch to an edifice at which others may have been working for years, but who are liable to be forgotten in the success and fame of the one who achieves the completion of the structure. This is peculiarly the case with photography.

It has been observed that the tanning of the skin by exposure to the sun's rays is as much a photographic action as is the blackening of *luna cornea*, or horn silver, the observation of which may be said to have been the first step in the science of photography. This horn silver is found in the mines of Freiberg. It is a vitreous, dully shining silver ore, and consists of silver and chlorine in chemical combination, and hence is known to science as chloride of silver. It can be artificially produced by passing chlorine gas over metallic silver. In its native state horn silver is

completely colourless, but so soon as it is exposed to the light of day it in the course of a few minutes assumes a violet tint.

This effect of light upon *luna cornea* appears to have been first observed by the alchemist Fabricius in 1556, and long after his time it attracted the attention of men of science, although without leading to any practical results.

In another substance containing silver this phenomenon is still more apparent. If silver be dissolved in nitric acid, and the solution be then evaporated, a solid mass of crystals is obtained. This is nitrate of silver, which fuses readily and destroys organic matter. Hence its use as a corrosive agent under the name of lunar caustic. Anything sprinkled with a solution of it very soon assumes a dark colour.

Many persons must have observed the blackening of paper under the action of lunar caustic, in which lay the primary secret of photography, and yet it was long years before any one thought of the uses to which it might be applied in the production of pictures by means of light.

The first person of whom we have any record who attempted to turn to account this property of silver nitrate to darken under the influence of light appears to have been a German physician, Johan Heinrich Schultze, of Halle, who, in 1727, attempted by means of written characters upon a surface prepared with a mixture of chalk and a solution of silver nitrate to take copies therefrom on paper that had been made translucent. The experiment, however, attracted very little attention, and probably was not very successful. Nothing material was added to these results until, in 1777, the famous Swedish chemist, Charles William

Scheele, took up the discovery of Fabricius, and applying combined chemical and spectrum analysis to the science of photography, found that the violet rays of the spectrum act more energetically upon silver chloride than the blue, yellow, or red rays, or in other words, than the less refrangible rays. He thus proved that the rays of light are not all alike chemically active.

These results were confirmed a few years later by Senebier, who found that the violet rays in fifteen seconds blackened silver chloride as much as the red rays did in twenty minutes.

Scheele, however, went further than this. Exposing silver chloride to the action of sunlight under water, and when the white salt had darkened, pouring away the water and adding a little silver nitrate, he found a white substance was formed which proved to be silver chloride (caused by the silver nitrate combining with chlorine dissolved in the water). He thus demonstrated that the effect of sunlight upon chloride of silver is to decompose it, and so compel it to give up a part if not the whole of its chlorine.

This important discovery was carried still further in 1801 by Ritter of Jena, who demonstrated the existence of rays lying beyond the violet limit of the solar spectrum, and that they too had the power of darkening silver chloride.

Ritter also announced "that the red rays have the property of undoing the work effected by the violet;" but he appears to have misunderstood the cause of the action. Similar results were obtained by Wollaston, the English chemist, in 1803. He found that gum guaiacum, when exposed to the influence of the blue rays, became

changed in colour, and that on exposing those altered portions to the red rays the original tint was restored.

It is claimed by the French that the first actual photograph was taken by Professor Charles, who, struck with the property possessed by silver salts to blacken in contact with light, made some interesting experiments in a course of lectures on physics delivered by him at the Louvre in 1780. By means of a strong ray of light he threw the silhouette of one of his pupils upon a sheet of paper that had been saturated with chloride of silver. The paper, under the action of the light, blackened immediately at those parts which were exposed to the sun's rays, while it remained white in those parts where the shadow fell, so that the figure of the youth was shown in white upon a black ground. But as soon as the shadow was withdrawn, the white, exposed to the sun's rays, began to darken. M. Charles, however, left no account of his process, and considerable doubt has been thrown upon the reported achievement.

While up to the end of the eighteenth century the problem of drawing by light was still an unsolved one, it is curious to note that, among the hints and foreshadowings of photography that have been collected, one Frenchman made so apt a guess at sun-picturing that it amounted almost to a prophecy. The genius in question, Tiphaigne de la Roche, in the year 1760 published a book which he called "Giphantie" (an anagram of his name), and in which, amongst other Munchausenisms, he describes a method whereby a strange people, in whose land he is sojourning, produce pictures of objects. "You

know," says his guide, "that rays of light reflected from different bodies form pictures, paint the image reflected on all polished surfaces, for example, on the retina of the eye, on water, and on glass. The spirits have sought to fix these fleeting images; they have made a subtle matter by means of which a picture is formed in the twinkling of an eye. They coat a piece of canvas with this matter, and place it in front of the object to be taken. The first effect of this cloth is similar to that of a mirror, but by means of its viscous nature, the prepared canvas, as is not the case with the mirror, retains a fac-simile of the image. The mirror represents images faithfully, but retains none; our canvas reflects them no less faithfully, but retains them all. This impression of the image is instantaneous. The canvas is then removed and deposited in a dark place. An hour later the impression is dry, and you have a picture the more precious that no art can imitate its truthfulness." *

It is hardly possible to read this strange foreshadowing of the photographic art without feeling that De la Roche had been gazing upon the magic pencillings of the camera obscura, and that in imagination he had realised the problem which investigators a few years later were trying to solve.

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* Quoted from "A History of Photography," by W. J. Harrison, F. G. S.

CHAPTER II.

THE OPTICS OF PHOTOGRAPHY.

PHOTOGRAPHY is the joint child of optics and chemistry. All that has been discovered about the influence of light upon the salts of silver and analogous substances might have been known, and yet, without the "dark chamber," the art of photography would have remained non-existent. It may even be said that the prior discovery of the camera obscura made photography possible. This simple instrument was the invention of Giambattista della Porta of Padua in 1569. The principle of it will be best understood by the simple experiment of darkening a room by closing the window-shutters, and admitting a ray of light through a small hole in them. If a sheet of white paper be fixed at a little distance from this aperture, the figures of external objects will be seen delineated upon it; and, by putting a small lens over the aperture, they are rendered much more evident from the condensation of the rays by the spherical glass. This will be readily understood by the following diagram (Fig. 1). Let C D be a window-shutter having a small aperture at A, and E F a piece of paper placed in a dark chamber. If now an illuminated object, R G B, be placed on the outside of the shutter, we shall observe an inverted image of this object depicted on the paper E F at B G R.

In order to understand how this inversion takes place, let us suppose the object R G B to have three distinct colours, red at R, green at G, and blue at B; then it is plain that the red light

from R will pass in straight lines through the opening A and fall upon the paper at R. In the same way, the green from G, and the blue from B, will respectively fall upon the paper at G and

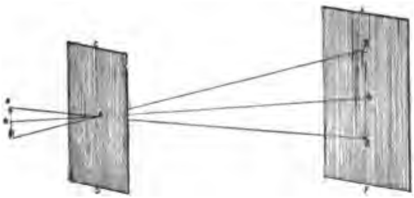

FIG. 1.

B, and an inverted image B G R of the object R G B will be depicted upon it.

If, instead of a darkened room, we substitute a darkened box (Fig. 2), the same effect will be perceived. Suppose, in the first place, the box to be without the lens, the rays would pass from the external arrow in nearly right lines through the aperture, refracted only in passing the solid edges of the opening, and form an image on the back of the dark box. The lens refracts the rays, and a

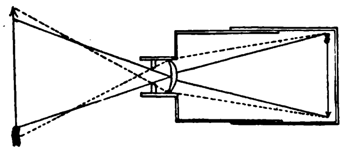

FIG. 2.

smaller, but a much clearer and more perfectly defined image is the result. Such, briefly, is the principle of the camera obscura, the basis of the camera of the photographer.

It will be seen that, whether as regards the chemicals he uses or the instrument with which he works, light is the subtle agent, the grand motive power, wherewith the photographer produces his effects. Without going, therefore, into the nature of light, it will be well to enter a little into some of the laws governing its action which have a relation to photography.

A ray of light passing through a vacuum progresses in a perfectly straight line, and were it possible under such conditions to gaze at a brilliantly illuminated point, we should see it in its true position, that is, the rays coming directly to the eye. But all transparent matter, however attenuated it may be, has the property of bending or refracting the light ray. Hence we do not see the stars in their true positions, owing to the refracting power of the atmosphere.

The law of refraction may be demonstrated in the following simple manner. Take a bowl, and in the bottom of it place a shilling; then move away until the eye loses sight of the coin, when it will appear as in Fig. 3, A representing the

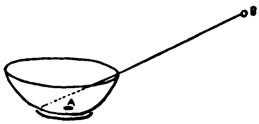

FIG. 3.

shilling and B the eye of the observer. The coin is of course invisible. Now let some one pour water into the bowl, taking care the while to keep the eye fixed on the same spot. The shilling gradually becomes more and more visible,

until it comes entirely into view. The explanation of the phenomenon is that the ray of light-producing vision in the eye is refracted, or bent back, as in Fig. 4; C representing the water and A B the ray of light refracted.

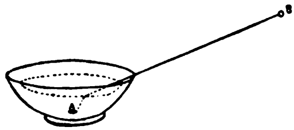

FIG. 4.

The refractive power of water is also observable when we thrust a straight stick into it. The stick seems to be bent. Hence persons spearing fish have to aim at a point below the object of their aim, else the weapon will miss by striking too high. Another illustration of refraction is to allow a sunbeam S (Fig. 5) passing through an

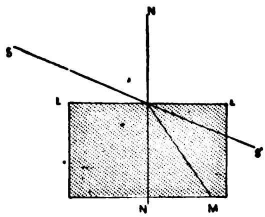

FIG. 5.

aperture in the window-shutter of a darkened room to fall upon the surface of a fluid contained in a glass vessel L L; instead of proceeding to S′, it will be found to alter its course on entering the fluid, and pass along the line to M. A ray of

light, however, striking a refracting medium perpendicularly, as the ray N (Fig. 5), suffers no refraction.

The amount of bending back a ray undergoes depends on the comparative density or rarity of the substance through which it goes. If the medium which the rays enter be denser, they pass through it in a direction more closely approximating to the perpendicular. On the other hand, when a beam of light passes obliquely out of a denser into a rarer medium it proceeds in a direction further from the perpendicular. This refraction is greater or less according as the second medium through which the rays pass is more or less dense than the first.

In proof of this, take an upright vessel into a dark room, which admits but a single slanting ray of light through an aperture in the shutter. Let the vessel stand on the floor, a few feet from the window admitting the light, and let it be so placed that, as the pencil of light descends towards the floor, it just passes over the top of the side next the window, and strikes the bottom on the side farthest from the window. Let the spot where it falls be marked. Now, on filling the vessel with water, the ray, instead of striking the original spot, will fall considerably nearer the side towards the window. If salt be added to the water in such quantity as to form a dense solution, the point where the ray strikes the bottom will fall still nearer the window. So, if alcohol be substituted for water, the refraction will be greater; and greater still should oil be used.

These laws of refraction are of the utmost importance to the photographer, inasmuch as it is by their careful study and application that the

optician is enabled to fashion lenses to meet his needs.

By a lens is meant what is commonly called a magnifying glass, which may be composed of any transparent substance, but in its application to photography it is generally made of glass—flint or crown—as colourless as can be obtained.

Lenses are of different shapes, and thence derive different names. The following figures represent sections of the variously shaped lenses used in photography.

A, B and C are convex or converging lenses, D, E and F concave or diverging lenses.

A is a double convex, and is used for magnifying objects, as in spectacles, telescopes, microscopes, and other similar instruments. B is a plano-convex, flat on one side and convex on the other. C is a meniscus or periscopic lens, convex on one side and concave on the other, both surfaces meeting, and of which we have an example in watch-glasses. D is a double concave lens.

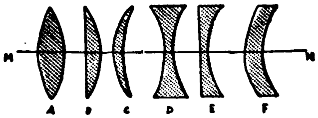

FIG. 6.

E is a plano-concave, or plane on one side and concave on the other. F is an example of the convex-concave or negative meniscus lens, in which the surfaces disagree, or do not meet when continued.

In all these lenses there is an imaginary line, represented by M N, and passing through the centres of the surfaces, which is called the axis.

Thus, when the axis of a lens is spoken of, it means a line passing through it perpendicular to its surface. In converging lenses the rays of light passing through them unite at a point, called the focus, some distance beyond the surface. Diverging lenses, on the other hand, cause the rays of light to go further apart, and are concave in form with broad edges. Of the varied qualities of these lenses it will be necessary to speak in a subsequent chapter; it suffices here thus briefly to distinguish them.

It was Porta's knowledge of the powers of lenses that suggested to him the idea of placing an objective in the orifice of the dark box, so as to bring the image produced as nearly as possible to a fixed point, and thus to reduce the camera to small and portable dimensions. The lens Porta used was a plano-convex, the rounded face being turned to the ground-glass. By thus hitting upon his ingenious contrivance he unconsciously took an important step in the evolution of the photographic art.

CHAPTER III.

WEDGWOOD AND DAVY'S EXPERIMENTS IN PHOTOGRAPHY.

NOTHING further appears to have been done in regard to photography until Thomas Wedgwood, a son of the famous potter, took up the subject, and succeeded in producing a photograph by making use of Scheele's observations on chloride of silver. He was, however, unable to fix his pictures, which blackened and disappeared as soon as

they were exposed to diffused light. He was assisted in these experiments by Humphrey Davy, then just rising into fame as a chemist, and in 1802, after Wedgwood's death, Davy prepared an account of the experiments they had made, and the results obtained, in the *Journal of the Royal Institution* for 1802. In this paper the process they adopted is described as "a method of copying paintings upon glass, and of making profiles by the agency of light upon nitrate of silver, with observations by H. Davy."

Wedgwood placed flat bodies, such as the pinatifid leaves of plants, upon paper that had been prepared with nitrate of silver. By this means, when exposed, the light was kept from passing through the paper covered by the objects. Those parts remained white, whilst the uncovered portions of the paper were blackened by the light. Hence there was produced a white outline of the superimposed objects upon a black ground (Fig. 7).

Another experiment which Wedgwood and Davy tried was to place a solar microscope in the aperture of a camera obscura in order, if possible, to fix on sensitized paper the image produced on the screen. They fastened a sheet of paper saturated with a silver salt at the spot where the image fell, and left it there for several hours—though without result.

As these experiments in sun-drawing are of great importance in the history of photography, the following extracts from the paper published in the *Journal* describing the experiments of the joint investigators will be of interest, as being the first published account of the production of photographic pictures.

"White paper, or white leather, moistened with a solution of nitrate of silver, undergoes no change when kept in the dark; but on being exposed to the daylight it speedily changes colour,

FIG. 7.

and after passing through different shades of grey and brown, becomes at length nearly black. The alterations of colour take place more speedily in proportion as the light is more intense. In the direct beam of the sun, two or three minutes are sufficient to produce the full effect; in the shade several hours are required; and light transmitted through different coloured glasses act with different degrees of intensity. Thus it is found that

red rays, or the common sunbeams passed through red glass, have very little effect upon it. Yellow and green are more effective, but violet or blue produce the most powerful or decided effect.

"When the shadow of any figure is thrown upon the prepared surface, the part concealed by it remains white, and the other parts speedily become dark. For copying paintings on glass the solution should be applied on leather; and in this case it is more readily acted on than when paper is used. After the colour has been once fixed on the leather or paper, it cannot be removed by the application of water, or water and soap, and it is in a high degree permanent. The copy of a painting or a profile, immediately after being taken, must be kept in an obscure place; it may, indeed, be examined in the shade, but in this case the exposure should only be for a few minutes; by the light of candles or lamps, as commonly employed, it is not sensibly affected. No attempts that have been made to prevent the uncoloured parts of the copy or profile from being acted upon by light have as yet been successful. They have been covered by a thin coating of fine varnish, but this has not destroyed their susceptibility of becoming coloured; and even after repeated washings, sufficient of the active part of the saline matter will adhere to the white parts of the leather or paper to cause them to become dark when exposed to the rays of the sun. Besides the applications of this method of copying that have just been mentioned, there are many others; and it will be useful for making delineations of all such objects as are possessed of a texture partly opaque and partly transparent. The woody fibres of leaves, and the wings of insects,

may be pretty accurately represented by means of it; and in this case it is only necessary to cause the direct solar light to pass through them, and to receive the shadows upon leather.

"The images formed by means of a camera obscura have been found to be too faint to produce, in any moderate time, an effect upon the nitrate of silver. To copy these images was the first object of Mr. Wedgwood in his researches on the subject, and for this purpose he first used nitrate of silver, which was mentioned to him by a friend as a substance very sensible to the influence of light; but all his numerous experiments as to their primary end proved unsuccessful. In following these processes, I have found that the images of small objects, produced by means of the solar microscope, may be copied without difficulty on prepared paper. This will probably be a useful application of the method; that it may be employed successfully, however, it is necessary that the paper be placed at but a small distance from the lens."

In this record it is stated that the experiments went to prove that muriate of silver was more readily acted upon by the light than the nitrate.

Here we have most of the elements of the great discovery, the chief thing lacking being the power to fix or render permanent the images. Some years later (1810–'11) Seebeck carried these discoveries as to the coloration of chloride of silver still further. He showed that the violet rays turn it brown, the blue producing a shade of blue, the yellow preserving it white, and the red constantly giving a red shade to the salt.

In order to explain their various effects properly it will be necessary to enter a little more fully into the composition of light.

A beam of light is composed of a bundle of rays, a ray being the smallest portion of light that can emanate from a luminous body. Every one of such rays possesses distinctive qualities, both as regards their chemical functions and their colours. Sir Isaac Newton demonstrated that the white light emitted from the sun is composed of rays of different colours and tints. The way in which he made plain this fact was by means of a prism, which is the name given to a triangular piece of glass used in optics (Fig. 8), so placed in

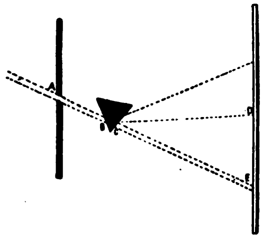

FIG. 8.

a darkened room as to receive upon one of its surfaces a ray of light from a small aperture bored in the window-shutter.

Before the prism is fixed in position the sunbeam entering the aperture at A will fall upon the white screen at E. But as soon as the prism B C (Fig. 8) is fixed in the path of the sunbeam, thus enabling it to fall on the side B, the ray will be refracted, or bent out of its course, and pass to the back of the prism (as in the line D),

instead of along the line A E, which it would otherwise have taken if the prism had not been interposed.

This, however, is not all: for in place of the simple round spot of light which fell upon the screen at E prior to the interposition of the prism, we see that an elongated, delicately-coloured image has been formed at D. If we now stand a short distance from the prism it will be seen that these colours are spread out in a triangular form, the base of which is on the screen, and the apex, or point of origin, at the back (C) of the prism.

This coloured image is known as the prismatic or solar spectrum, which, according to Newton's theory is composed of seven different colours (Fig. 9). The colour at the lower portion of this image, or that nearest to the round white spot at E on the screen, when the prism was away, is of a red colour, and the one at the opposite end is violet; the intermediate space being occupied by five other colours, indigo, blue, green, yellow, and orange, coming in rotation between the violet and the red. Or, as the poet puts it:

First the flaming red
Sprung vivid forth: the tawny orange next;
And next delicious yellow; by whose side
Fell the kind beams of all-refreshing green,
Then the pale blue, that swells autumnal skies,
Eternal played; and then, of sadder hue,
Emerged the deepened indigo, as when
The heavy-skirted evening droops with frost,
While the last gleamings of refracted light
Died in the fainting violet away.

Newton was of opinion that these seven were all primary colours, and that each was possessed of

a certain degree of refrangibility. Later investigations, however, have tended to reduce the number of colours to six, namely, red, orange,

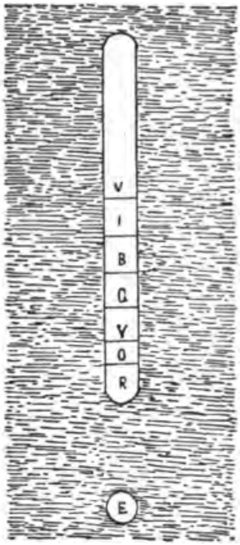

FIG. 9.

yellow, green, blue and violet; and despite Brewster's contention that there are only three primary colours, red, yellow, and blue, the others being composed of the overlapping of these, it is now generally held that each of the six colours above named are primary.

As we have seen, since Newton's time researches into the nature of the spectrum have been greatly extended. From experiments made

in 1812, M. Berard demonstrated that chemical intensity is greatest at the violet end of the spectrum, and that it extends, as Ritter and Wollaston had previously noticed, a little beyond that extremity. He concentrated by means of a lens all that part of a spectrum comprised between the green and the red, and by means of another lens, all that portion between the green and the violet. By this experiment he found that the chloride of silver, placed at the focus of the first bundle of rays, underwent no modification after an exposure of two hours, while that which was placed under the focus of the second group, which was much less bright and less hot, blackened in a very few minutes.

It has been found that the upper or invisible violet end of the spectrum can be made visible by allowing it to fall upon some suitable fluorescent substance, such as uranium glass, or a solution of quinine. Indeed, by properly choosing the sensitive substance, photographs can be taken of any part of the spectrum, from a reduction of nearly four times the wave length of the red rays up to the highest chemical rays known to exist.

Upon these experiments was based the theory, which subsequent investigations have fully borne out, that there exist three spectrums one above the other, namely a calorific or heat spectrum, a colorific, and a chemical spectrum. It is further established that each of the substances which compose the three spectrums, and even each molecule of unequal refrangibility which constitutes these substances, is endowed, like the molecules of visible light, with the property of being polarized by reflection, and of escaping from re-

flection in the same positions as the luminous molecules.

Since the above experiments were made a great deal of attention has been paid to this subject, and our knowledge of the properties of the spectrum has been greatly advanced. It will suffice here, however, to say that the ultra violet rays perform certain chemical actions, and make various substances shine in the dark. The infra-red rays, on the other hand, have no chemical properties, and quench luminosity. What they do is to warm the substances on which they fall, and hence are called calorific waves. Maxwell in 1867 propounded the brilliant theory that all light waves, visible and invisible, are really electric vibrations, and recent discoveries have proved the truth of the hypothesis.

Of the real nature of the light rays, beyond this generalisation, little is known. Various theories have been advanced respecting them; but into these it is not necessary for our present purpose to enter. What concerns us more nearly is the fact that a sunbeam—the ray of white light—contains within it powers of which the earlier philosophers had but a faint idea. Besides its accompanying heat, it has the power of decomposing and determining the recomposition of chemical components. This principle—known as actinism—is as perfectly distinct in the nature of its properties from light, as light is from the principle of heat, with which it is so closely connected.

Actinism is regarded by some as the fundamental principle upon which photography is based. That principle is a component part of light, but not light itself. In explanation of this

seeming anomaly it may be explained that, of the prismatic spectrum, the violet end possesses the greatest reducing or decomposing power, that is, the violet part of the decomposed portion of light, and still more strongly the invisible rays beyond it, exerts the most powerful influence upon the unstable metallic salts, reducing them speedily to their bases.

What may be called the varying actinic powers of the different colours can be demonstrated by a very simple experiment. Take a piece of sensitized paper, and place on it three pieces of coloured glass, red, yellow and blue. Expose the whole to the sun's rays for a short time, and it will be found that the paper has become rapidly discoloured under the blue glass, but remains unchanged under the red and yellow, although the last is by far the most transparent. It is this property possessed by red and yellow of intercepting the actinic rays of light that makes them so useful in practical photography for the construction of the "dark room."

CHAPTER IV.

NIÉPCE AND HELIOGRAPHY.

THE next person to take up the subject of sun-pictures, and carry it forward from the point where Wedgwood and Davy had left it was a Frenchman named Niépce. Indeed, although his name was for years eclipsed by another, there is no doubt that to Niépce belongs the largest share of the honour due for the invention of photog-

raphy, or, as he called it, heliography (from *helios*, the sun).

Joseph Nicéphore Niépce was born at Châlon-sur-Saône in 1765. His father, Claude Niépce, was a "conceiller de roi," and in easy circumstances, his mother the daughter of a distinguished lawyer named Barrault. As a youth Niépce was of a dreamy and poetical turn, and did not show any particular inclination to choose a profession. In 1792, however, he entered an infantry regiment as sub-lieutenant, and in the following year saw active service in Sardinia and Italy. Shortly afterward he was obliged to resign his commission in consequence of ill-health and failing sight.

In 1794 he was appointed a member of the administration of the district of Nice. Continuing to hold this position until 1801, he then relinquished it to follow what had always been his chief bent, study and research. Returning to his native place, he there devoted himself, along with his elder brother, to scientific investigation. Several mechanical inventions which he made received from M. Carnot, the Minister of Finance, the most flattering encouragement; while his researches in reference to the colouring matter of pastel attracted the attention of the commission charged with the examination of substances suitable for dyeing.

All these labours, however, are now forgotten in the invention with which his name is chiefly associated, which absorbed the last twenty years of his life, and cost him the fortune that he had inherited from his father.

Lithography, which was then but newly invented, and was consequently much talked about,

greatly interested Niépce, and he devoted much time in the endeavour to improve the process. At first he replaced the stone by a plate of tin; "then," says one of his biographers, "in 1813 he was seized with the idea of finding a substitute for the lithographic chalk with which the designs were drawn, and the almost fantastic idea took possession of his mind that they might be done by light itself." From that moment he could think of nothing else—could work at nothing else.

Niépce was acquainted of course with the quality possessed by chloride of silver of becoming dark when exposed to the light. From this fact he was led to infer the possibility of reproducing designs and engravings by rendering the paper transparent, and applying the design or picture to a surface to which had been given a coating of silver salt. The dark parts, preventing the passage of light, would leave the parts corresponding to the salt white. Thus a "negative" would be produced, which, by a second operation, would exactly reproduce the original.

The idea was simple enough, and seemed feasible. In practice, however, the thing could not be done. There was no difficulty about the production of the negative; but as soon as it was exposed to the light the white portion became dark, and the design was quite obliterated.

In short, he had repeated the experiment of Wedgwood and Davy, and found himself confronted with the same difficulty which stopped them. The question that Niépce now had to solve was, how could the sun, after it had produced a picture, be prevented from destroying it.

This second effort was a more successful one. He discovered—it is not known how—that as-

phalt, or bitumen of Judea, a substance which is found in the Dead Sea, the Caspian, and other places, possesses the quality of becoming soluble in ethereal oils, such as oil of turpentine, oil of lavender, petroleum, ether, etc. This property Niépce made use of in a most ingenious way. He poured a solution of bitumen upon a metal plate, and allowed it to cover the surface, which soon dried in the form of a brown film. Taking a plate thus coated, he placed it where the image of the camerà obscura falls, and then exposed it to the light, the result being that the asphalt remained soluble on the dark parts, that is, the shadows, of the image, while the light parts became insoluble. The eye does not perceive these changes; but if oil of lavender be poured over the exposed film of asphalt it dissolves those parts that have not been changed, leaving behind only those that have been affected by the light, that is, the parts which have been rendered insoluble. Thus, after several hours' exposure in the camera, and subsequent treatment with essential oils, Niépce succeeded in obtaining a picture—a picture traced upon the metal plate in lines of asphalt.

He now went a step further, and made the attempt to utilise his discovery as a substitute for engraving on copper. To produce a copper-plate print, a smooth plate of copper is engraved with a tool for that purpose called a burin, the lines that are to appear black in the picture being cut into the plate. In order to obtain impressions, ink is rubbed into these lines, then a sheet of paper is laid upon the plate and placed under a roller-press, which causes the ink to be transferred to the paper, thus producing a "print" of the inked lines.

Niépce's idea was to produce these lines in the

copper by the action of light; and to effect this object he covered the copper-plate with bitumen, and exposed it to the light beneath a drawing on paper. The black lines of the drawing of course prevented the light from reaching the bitumen on the plate. Accordingly in those parts not affected by the light the bitumen remained soluble, while in those parts where the light had penetrated the white paper, it became insoluble. When, therefore, oil of lavender was subsequently poured over the plate the portion of the bitumen which had been rendered insoluble adhered to the copper, whilst the other parts were dissolved and washed away. Thus on the film of asphalt the original drawing appeared as if engraved.

A corrosive acid was now poured upon the plate, and acted on the metal when not protected by the asphalt, eating into it, in fact. Thus an incised drawing was produced by the action of the acid, and, after cleaning, could be printed from in the same manner as a copper-plate engraved by hand.

Copper-plate prints of this description were found amongst Niépce's papers after his death. These, which he called "heliographs," he is known to have shown to his friends as far back as 1826.

This method in an improved form is in use today, and is especially useful in the printing of bank notes, where it is necessary to have a number of plates all absolutely alike, so that one note may be an exact fac-simile of another and be easily distinguishable from counterfeits. Some of the notes of the German States, notably Prussia, are thus produced.

The original inventor of the method, however was not able to attain that perfection in his im

pressions which subsequent experimenters succeeded in achieving. Not being satisfied therewith himself, Niépce relinquished his labours in this direction and devoted his attention to other lines of research in regard to fixing the images of the camera obscura. But it was unquestionably these discoveries that led in the end to one of the most useful applications of photography, the combination of photography with copper-plate printing above described.

In his description of the method he employed Niépce recommends that the asphalt or bitumen be reduced to a powder and the oil of lavender dropped upon it in a wine-glass, and then gently heated. A metal plate, highly polished, was covered with this solution, and when dry it was ready for employment in the camera. For his engravings Niépce preferred plate of silvered copper.

In 1827 Niépce went to England on a visit to his brother Claude, who was living at Kew, where he had settled many years previously with the object, apparently, of pushing some ingenious inventions, the joint production of himself and Nicéphore. Here he was introduced to Dr. Bauer, the Secretary of the Royal Society, and through him endeavoured to bring his discovery before that body; but as Niépce refused to make known his process his communication was not accepted.

It is to be presumed that the paper which he offered to submit to the Royal Society was subsequently lost or destroyed, as no account of his method was ever published by Niépce; and the only description thereof that we have is one contained in an agreement made between him and his collaborator, Daguerre, in December, 1829. In that document he says: "The discovery which

I have made, and to which I give the name of heliography, consists in producing spontaneously, by the action of light, with gradations of tints from black to white, the images received by the camera obscura. Light acts chemically upon bodies. It is absorbed; it combines with them, and communicates to them new properties. Thus it augments the natural consistency of some bodies; it solidifies them even, and renders them more or less insoluble, according to the duration or intensity of its action. The substance which has succeeded best with me is asphalt, dissolved in oil of lavender. A tablet of plated silver is to be highly polished, on which a thin coating of the varnish is to be applied with a light roll of soft skin. The plate, when dry, may be immediately submitted to the action of light in the focus of the camera. But even after having been thus exposed a length of time sufficient for receiving the impressions of external objects, nothing is apparent to show that these impressions exist. The forms of the future picture remain still invisible. The next operation then is to disengage the shrouded imagery, and this is accomplished by a solvent, consisting of one part by volume of essential oil of lavender, and ten of oil of white petroleum. Into this liquid the exposed tablet is plunged, and the operator observing it by reflected light, begins to perceive the images of the objects to which it had been exposed, gradually unfolding their forms. The plate is then lifted out, allowed to drain, and well washed with water."

Niépce goes on to say: "It were, however, to be desired that, by blackening the metal plate, we could obtain all the gradations of tone from black

to white. The substance which I now employ for this purpose is iodine, which possesses the property of evaporating at the ordinary temperature."*

CHAPTER V.

DAGUERRE AND HIS DISCOVERIES.

IN the meanwhile another Frenchman had been engaged in a similar line of investigation to that which had so long riveted Niépce's attention. This was Louis Jacques Mande Daguerre, to whom for many years was given the chief honor in connection with the discovery of photography. Daguerre was born at Cormeilles, a village in the department of the Seine-et-Oise, not far from Paris, in 1787. Occupied at first as an Inland Revenue officer, he after a while threw up that avocation, and turned his attention to scene-painting for the opera. He studied under Degote, and soon surpassed both him and his predecessors Bibiena and Munich, especially in the remarkable power he developed of representing light and shade. He was, for a time, engaged with M. Prévost in the production of panoramic views of Rome, Naples, London, Jerusalem, and other places, and in 1822, in conjunction with another, he produced his famous Diorama, the pictorial effects of which were heightened by the alternate use of reflected and transmitted light. In the preparation of his pictures Daguerre frequently employed the camera obscura to obtain

* "A History of Photography."

his first sketches from nature; and it appears to have been the hopelessness of imitating the perfection and beauty of the originals as presented on the screen of the dark chamber, that turned his thoughts to the finding out of some means of rendering the evanescent shadows permanent. The Diorama enjoyed great vogue in Paris until 1839, when it was accidentally destroyed by fire. This stroke of ill-luck, however, was soon more than compensated for by the fame the artist achieved as the inventor of the Daguerrotype process of photography.

How far Daguerre had gone in his investigations when, in the early part of 1826, he learned that the problem on which he was engaged had already been solved by a gentleman at Châlons-sur-Saône we do not know. But, putting himself in communication with Niépce, he received from him several plates of metal acted upon by his heliographic process, and also some engravings taken from them. In return, however, he either would not, or could not, give any specimens of his own labours, or particulars of the results he had achieved, beyond affirming that he had constructed a greatly improved camera, which afforded a more certain means of effecting the fixation of images. Finally they met, and Niépce proposed that they should unite their efforts with a view to making the most of their inventions. To this Daguerre agreed, and the deed of partnership, already referred to, was drawn up and signed at Châlons-sur-Saône in 1829, at which time Niépce made his process fully known to his collaborator.

From this time until the death of Niépce in 1833 the two investigators worked together for

the perfecting of the heliographic process, and it is said that Daguerre succeeded in making such improvements in the invention that Niépce was as much surprised as rejoiced at the results obtained.

Daguerre, in the place of bitumen, experimented with the resin obtained from the distillation of the essence of lavender. When a plate covered with this substance had been exposed to the action of light, he subjected it to the vapour of the essence of lavender. This method, however—whether by the use of asphalt or the lavender resin—required a long exposure to the light, and after a time the picture was in part effaced.

Abney has a theory that it was from the experiments with bitumen that Daguerre obtained his first idea of the method that bears his name. The image formed by the asphalt on the silver plates (which Niêpce employed) was brown, the shadows being represented by the metallic surface. "In order to produce a proper effect, it was necessary that the parts covered by the bitumen should be whitened and the bare parts darkened. After various experiments he applied iodine to the picture, subsequently removing the bitumen. It is to be presumed that Daguerre noticed the action that the light produced on those portions of the plate which had been covered with iodine. At any rate to Daguerre belongs the glory of the discovery that an image could be produced on a silver plate which had been exposed to the action of iodine." *

These images were produced by exposing

* "Treatise on Photography."

plates of silver to the vapour of iodine (a peculiar and very volatile chemical element). Under this treatment the silver assumes a pale yellow colour. When exposed to the light plates thus prepared assume a brown colour, and when exposed to the action of light in the camera a picture is formed upon them. But in order to produce such a picture a very long exposure to the light is necessary.

At length—some time subsequent to the death of Niépce—Daguerre was accidentally led to the discovery that an image is formed by the luminous rays upon a plate covered with iodide of silver which is invisible under ordinary conditions, but which appears as soon as the plate is exposed to the vapour of mercury. Thanks to this discovery, photography upon metallic plates, or daguerrotype, was created.

The way in which this discovery was made is both curious and interesting. One day Daguerre placed several plates that had been exposed too short a time to the light in a closet where were some chemicals. They were condemned as useless because no image had appeared. But, after a time, happening to look at the plates, he was astonished to see a picture upon them. He immediately came to the conclusion that this effect must have been produced through the operation of some chemical substance which was lying in the closet. By removing the chemicals one after another, and placing in the closet plates that had been exposed too short a time to the light, and still finding images produced upon them, he concluded that the culprit was a dish containing mercury; that substance giving off vapour at an ordinary temperature.

In order to test the truth of his supposition, Daguerre again took a plate that had been exposed for a short time in the camera obscura, and on which no picture was yet visible. Subjecting it to the action of the vapour of mercury, he found, to his intense delight, that the picture appeared. Thus by a happy accident, the world was made the richer by a most valuable discovery.

This was the cardinal point in Daguerre's discoveries. While others before him had sought to produce a visible picture by means of light, for which long exposure was necessary, he succeeded in hitting upon a process by which he obtained an invisible or "latent" picture after a short exposure, and then by a second process "developed," or brought it to light. By this fortunate discovery an enormous advance was made in photography.

Hardly less important was the discovery which soon followed whereby the image thus obtained could be fixed by immersing the plates after development in a strong solution of common salt, which dissolved and washed away the iodide of silver that had been acted upon by the light. Subsequently, however, Daguerre adopted hyposulphite of soda as a solvent of the silver salt. This substance was discovered by Chaussier in 1799, and shortly after the daguerrotype process was made public in 1839 Sir John Herschel pointed out its superior qualities for clearing and fixing the light-produced picture.

According to the terms of the agreement made between Niépce and Daguerre in 1829, the names of both the inventors were to be attached to their discovery; but after Niépce's death, his son consented to the first agreement being replaced by

another, by the terms of which Daguerre was to throw into the partnership a new process he had discovered which would produce pictures ten or twenty times quicker than that discovered by Niépce, on condition that the new process should bear only the name of Daguerre.

Thus it was that practical photography was first presented to the world under the name of daguerrotype.

It has been asserted that the too confiding Niépce was deluded out of the honour of his invention by his sharper and more business-like partner. That may be putting the matter too strongly; but one cannot help feeling that Daguerre acted ungenerously in thus giving his name exclusively to an invention which, to give him all possible credit, was only in part his, and that part perhaps the lesser one.

In order to make the most of his discovery, Daguerre appears to have tried to form a company to work it; but, failing in the attempt, he made known his process to M. Arago, the celebrated astronomer and physicist, and in accordance with his advice an announcement respecting it was made to the Academy of Sciences on the 9th of January 1839; although the details of it were not communicated until the month of August following. On the 30th of July of the same year, in consequence of the representations made by M. Arago and others to the French Government, the daguerrotype process was purchased by the State and made public, the inventor and his partner receiving each a pension by way of remuneration, that of Daguerre being six thousand francs and that of Claude Niépce four thousand francs. Notwithstanding the invention was thus

given to "the world of science and of art," Daguerre took out a patent in England the same year.

According to Arago, Daguerre asked for four thousand francs for himself and four thousand for Niépce, but that an additional two thousand francs was given to him on condition that he should make known his system of transparent and opaque painting in the production of his dioramas, and that he should also give to the public any future discovery he might make in connection with photography. In further recognition of his discovery Daguerre was made an officer of the Legion of Honour.

The only important improvement in his process subsequently made by Daguerre was in the preparation of his plates. This was based on the use of iodine and bromine, and was published in 1844. But prior to this (in 1840) Mr. Goddard, a lecturer on science in London, had made known his method of employing bromine in conjunction with iodine for increasing the sensitiveness of plates. A further impulse in the same direction was given by M. Claudet in the following year by the use of chlorine vapour to the same end. Accelerators of this kind—and a number of them were soon discovered—are not of themselves photogenic, that is to say, capable of being influenced directly by light, but applied to a surface already prepared with iodide, they communicate to the iodine the faculty of being impressed in a few seconds. By means of plates prepared either with bromine or chlorine vapour, the time required to produce a picture in the camera was reduced to a few minutes—indeed, with a bright light, to a fraction of a minute.

Up to this time photographic portraiture had not been possible: through these discoveries it soon became an accomplished fact. The first person to produce an actual portrait from life was Mr. Draper of New York, who was enabled to achieve that result by the use of enlarged lenses, as introduced by Mr. Towson of Liverpool.

Another valuable improvement in the daguerrotype process was introduced by M. Fizeau. Pictures produced by Daguerre's method were extremely perishable; a very little friction effaced them, while on exposure to the air they were soon darkened almost to obliteration. To do away with this defect M. Fizeau adopted a method of toning or gilding the picture with a solution of gold. Chloride of gold was mixed with hyposulphite of soda, and the plate, upon which a little of the solution had been placed, was heated over a spirit-lamp until the required strength was given to the picture. M. Fizeau, in his description of the process, says: "In this operation the silver is dissolved, and the gold precipitated upon the silver and mercury, but with very different results; in effect, the silver, which by its reflection forms the shades of the picture, is in some way darkened by the thin film of gold which covers it, from which results a strengthening of all the dark parts. The mercury, on the contrary, which, in the state of an infinite number of small globules, forms the lights, is augmented in its solidity and brightness by its union with the gold, from which results a greater degree of permanency and a remarkable increase in the lights of the picture." Most of the daguerrotype pictures still in existence have been subjected to this process.

According to Abney,* daguerrotypes may be reproduced by electrotypy, showing that the image, after development, is in relief, although to a very small extent. Sir W. R. Grove introduced a method of etching daguerrotype plates by means of hydrochloric acid, so that they could be printed from. The process, however, does not appear to have been turned to much practical account, having been superseded by more easily manageable and less expensive methods.

CHAPTER VI.

PHOTOGRAPHY ON PAPER AND ON GLASS.

WHILE Niêpce and Daguerre were perfecting their process, another investigator was working on similar lines, and arrived at like results by a different method. This was Henry Fox-Talbot, who is entitled to rank with the two Frenchmen as an independent discoverer in photography. Fox-Talbot was born at Laycock Abbey, Wilts, in the first year of the century, and was educated at Harrow and Trinity College, Cambridge, where he carried off the Porson prize for Greek verse in 1820, and graduated as twelfth wrangler in the following year. He sat in the first reformed Parliament for Chippenham; but, scientific investigations being more to his taste, he gave up politics after two years, and devoted himself to studies that led to a discovery which proved one of the first steps towards the realisation of photography.

* "Treatise on Photography."

Fox-Talbot tells us in his "Pencil of Nature," published in parts between 1844 and 1846, how, in attempting to make a drawing, by means of the camera obscura, of a landscape on the shores of Lake Como, his thoughts were turned by the imperfect attempts he made to copy the pictures of surrounding objects presented by the apparatus to the possibility of fixing by some chemical process those exquisite shadows. To the realisation of this idea he devoted himself with the utmost zeal and perseverance, and gradually arrived at a result that was as surprising to him as it was satisfactory.

He began his experiments in 1833, and his first method consisted, as described in the *Philosophical Magazine*, in soaking fine writing paper in a weak solution of common salt, then brushing one side of it with a 12 per cent. solution of nitrate of silver in water, and drying it at the fire. By repeating the process of saturating the paper with salt solution, and then coating it with the nitrate of silver, greater sensitiveness to light was produced. This increased sensitiveness was due to the use in combination of the two salts of silver, the nitrate being in excess.

Fox-Talbot states that by means of this paper, he was enabled to obtain in the solar microscope an outline of the object to be depicted in full sunshine in half a second; while, after an exposure of about an hour, he had the gratification of receiving an impression of the image cast by the lens upon the white paper in the camera obscura. To this point in his discoveries he had attained in 1835.

Thus far Talbot's process was the same as that by which Wedgwood and Davy had obtained

their results more than thirty years before; only he had succeeded in rendering chloride of silver much more sensitive to light than they were able to do. The problem, therefore, which had baffled those investigators yielded to the perseverance of Fox-Talbot. He found that by thoroughly washing his impressions, and then soaking them in a solution of common salt, or in a solution of potassium iodide or bromide, he turned them into permanent pictures. In short, he had discovered the secret of "fixing."

For six years Fox-Talbot kept the secret of his investigations to himself, and was only then impelled to divulge his process by hearing that a Frenchman had succeeded in fixing the silhouette of the camera obscura. On the 25th of January 1839, Professor Faraday described Fox-Talbot's method of "Photogenic Drawing," as the inventor called it, to the members of the Royal Institution; and a few days later the inventor himself read a paper before the Royal Society giving a full account of his process.

In this paper he says: "The first kind of objects which I attempted to copy by this process were flowers and leaves, either fresh or selected from my herbarium. These it renders with the utmost truth and fidelity, exhibiting even the venation of the leaves, the minute hairs that clothe the plant, etc., etc."

He proceeds: "At the very commencement of my experiments upon the subject, when I saw how beautiful were the images which were thus produced by the action of light, I regretted the more that they were destined to have such a brief existence, and I resolved to attempt to find out, if possible, some method of preventing this, or re-

tarding it as much as possible. The following considerations led me to conceive the possibility of discovering a preservative process.

"The nitrate of silver, which has become black by the action of light, is no longer the same chemical substance that it was before. Consequently, if a picture produced by solar light is subjected afterwards to any chemical process, the white and dark parts of it will be differently acted upon; and there is no evidence that after this action has taken place, these white and dark parts will any longer be subject to a spontaneous change; or, if they are so, still it does not follow that that change will *now* tend to assimilate them to each other. In case of their remaining *dissimilar*, the picture will remain visible, and therefore our object will be accomplished."

Applying this process of reasoning, Fox-Talbot, after some unsuccessful trials, "discovered a method which answered perfectly, and shortly afterwards another." After commenting on the marvellousness of the process by which "a shadow, the proverbial emblem of all that is fleeting and momentary, may be fettered," he has the following reflection on the value of scientific method. "This remarkable phenomenon," he says, "of whatever value it may turn out in its application to the arts, will at least be accepted as a new proof of the value of the inductive methods of modern science, which by noticing the occurrence of unusual circumstances (which accident perhaps first manifests in some small degree), and by following them up with experiments, and varying the conditions of these until the true law of nature which they express is apprehended, conducts us at length to consequences altogether un-

expected, remote from usual experience, and contrary to almost universal belief. Such is the fact, that we may receive on paper the fleeting shadow, arrest it there, and in the space of a single minute fix it so firmly as to be no more capable of change, even if thrown back into the sunbeam from which it derived its origin."

With this first success, however, Fox-Talbot did not rest satisfied. After seeing a description of Daguerre's process, he made some experiments with silver iodide in place of chloride, the process to which he gave the name of "Calotype" being the outcome. Paper already sensitive was brushed over with a mixture of silver nitrate and gallic acid, and then, in a half-wet state, exposed in the camera. By this method the time necessary to secure a picture was greatly reduced. Development was effected by an application of gallo-nitrate of silver, exposing the picture at the same time to a gentle heat.

In lighting upon gallic acid as a developer, Fox-Talbot showed a remarkable application of the induction process of reasoning. Daguerre had found that if his prepared plates were exposed to the light, even only for a few seconds, a picture could be obtained by afterwards exposing them to the action of mercurial vapour. As Talbot used for the preparation of his paper the same material Daguerre had on his plates, he concluded that the exposure of the paper for a few seconds to the action of light in the camera obscura must have produced an impression. Talbot was convinced therefore that there must be a picture on the paper, although he could not see the least trace of one. This conviction spurred him on to search for something that

would make the latent image visible, for he had no doubt such a thing was really to be found.

How came he then to employ for this purpose a solution of gallic acid?

The solution of this problem most persons might be inclined to attribute to chance, as was the case with Daguerre's pictures. Talbot's selection of gallic acid, however, was no haphazard affair. Daguerre had not placed the vessel of mercury in the cupboard in prosecution of his experiments. His pictures were obtained without his doing anything for this purpose. Talbot, on the contrary, racked his brains in the search after a means suited to his particular object. He had before his mind's eye many thousands of substances from which to choose, but his analytical faculty instinctively excluded from his survey all those that stood in no relation to his purpose, and directed him to those which acted in a similar manner when under the influence of light.

The salts of silver are blackened by gallic acid when slightly heated, as well as by light; the action of both is identical in kind, although gallic acid is much the more powerful of the two. The solar rays had, as he conceived, produced an action upon the prepared paper in the camera obscura, albeit so slight that it was not visible; perhaps—so he reasoned—this action might be carried on and augmented by means of gallic acid. Acting upon his thought, he tried the experiment. It was entirely successful, and the justness of the induction was thereby proved.

The "fixing" was done by washing in pure water, and, after drying, treating the paper with a solution of bromide of potassium, and again washing and drying. The paper "negative," as

it was called, was now rendered translucent with wax, and used for the production of positive prints.

This was effected by placing beneath the negative a piece of sensitized paper and then exposing it to the action of light. By this means a second impression was obtained, the image being in this case, so far as light and shade were concerned, the exact reverse of the first one. Talbot appears to have been the first to conceive the idea of thus making use of the negative for the purpose of getting a direct image, and hence may be said to have been the originator of photographic printing.

It should be said that the method of developing by means of gallic acid and nitrate of silver appears to have been first known and applied by the Rev. J. B. Reade, who, when taking objects in the solar microscope, employed those agents to render his silver chloride paper more sensitive. Fox-Talbot, however, laid claim to priority of discovery, and in an action at law to establish his right he gained the day, although he did so apparently on the technical point that he was the first to make publication of the discovery. That he made an independent discovery of the process, however, there can be no question.

In the Daguerrean process, as we have seen, the picture was produced upon metal plates, while in that of Fox-Talbot paper alone was used. The former was at first most employed, because the image was clearer than in the other. But the Talbotype (as it was named) soon became the more generally used, especially by amateurs, on account of the cheapness of the paper in comparison with the metal plates required in daguerrotype as well as by reason of the difficulty of obtaining

the plates. In 1841 Fox-Talbot had protected his Calotype (*i.e.* beautiful picture) process by patent; but he subsequently presented his patents to the nation, which of course had the effect of making his process more popular.

In 1842 the Royal Society presented him with its medal in honour of his discovery. His "Pencil of Nature," referred to above, is a collection of landscapes, portraits, fac-similes of engravings and lithographs, etc., produced by his process. In that work he says: "The chief object of the present work is to place on record some of the early beginnings of a new art, before the period, which we trust is approaching, of its being brought to maturity by the aid of British talent." Some of the works thus given to the public will bear comparison with much of the best and most artistic works of to-day. Unfortunately they show a tendency to fade—a thing not to be wondered at perhaps when we consider that they are the first fruits of photography.

Amongst other works Talbot published a description of the experiments he made in order to obtain instantaneous photographic pictures (1851), and a notice of his method of engraving on steel by means of light upon a surface composed of gelatine and bichromate of potash in 1853. In the latter, however, to which he gave the name of photoglyphy, he does not appear to have been very successful. Amongst Fox-Talbot's other contributions to photography may be mentioned his introduction of albumen to give a gloss to the surface of paper on which positives are printed.

Gradually the paper process of photography made headway, threatening totally to supersede the daguerrotype method, when, in consequence

of certain inconveniences attached to the use of paper—its grain, for instance, and the difficulty of getting it to lie flat in the camera—caused Niépce St. Victor, a cousin of the original discoverer of photography, to turn his attention to glass as a support for the sensitizing material.

St. Victor, like Nicéphore Niépce, was a soldier by profession. Nevertheless, he found time to devote considerable attention to scientific study and investigation. It was natural perhaps that his thoughts should turn to photography, and that he should endeavour to perfect the invention with which the name of his family was so intimately identified. He was not the first, however, to use glass as a support for the sensitive salts of silver, Sir John Herschel having some years before suggested, and even tried, its employment for that purpose.

In order to find out how far organic matter was necessary to the discoloration of silver solutions, Herschel prepared a very diluted solution of salt, which he mixed with muriate of silver. This was poured over a plate of glass, laid at the bottom of a shallow vessel. Gradually the white silver salt was deposited, in the form of a film, on the surface of the glass. The water was then removed by means of a syphon, and the glass left to dry. A solution of silver nitrate was now spread over the film, causing it to become highly sensitive. Exposed in this state in the camera, the silvered glass responded to the light by receiving a faint negative picture. But, although intensified to some extent by electro-deposition, it was found impossible to get good prints therefrom.

These experiments of Sir John Herschel were made public through the *Journal of the Royal So-*

ciety, and no doubt had the effect of turning the attention of many investigators to glass as a support. Amongst the number was Niépce St. Victor, who perceiving that Herschel had failed from not coating his glass plates with a layer of some suitable organic substance to serve as a nidus for the chemical particles to be submitted to the action of light, began experimenting with a view to discovering such a medium. As early as 1847 he had made such progress in the development of his idea as to be able to announce a discovery whereby through the instrumentality of a film of starch, he had succeeded in producing a photograph on glass. Unfortunately his labours were interrupted by the Revolution of 1848, during which troubles the barracks in which he had his laboratory were burned down. Being now for some time on the retired list, he made the most of his enforced leisure to continue his studies, and on the 12th of June 1848 he communicated to the Academy of Sciences his process of photography on glass by the use of albumen.

To make his negative, says M. Tissandier, St. Victor spread upon a plate of glass a thin layer of albumen, which forms a homogeneous coating, smooth and admirably adapted for the purpose required. To sensitize this film of albumen, the inventor saturated it with iodide of silver. For this purpose he plunged it first of all in a bath of iodide of potassium, then in a solution of nitrate of silver. When dry, the sensitized plate of glass served to obtain a negative impression in the camera. When the image was fixed St. Victor found it a comparatively easy matter to obtain positive prints from his glass negative.

This invention of the negative on glass ren-

dered an immense service to photography. Indeed, it produced a complete revolution in the art.

Although M. St. Victor does not appear to have reaped much advantage from his invention, decided step in advance though it was, in the hands of M. Blanquart-Evrard it produced practical results of a high order. It was soon carried to still greater perfection by M. Le Gray and others.

One of the many improved methods of preparing albumen then in use was as follows:—The whites of five fresh eggs are thrown into a deep dish and carefully beaten together with a whisk or wooden fork for two or three minutes; about 600 grains of iodide of potassium, 20 grains of bromide of potassium, and 10 grains of common salt are then added, and the whole again thoroughly beaten up until it is converted into a white froth. The mixture is then strained through muslin and allowed to remain at rest for ten or twelve hours, when the clear liquid is drained off into a suitable bottle. A sufficient quantity of the iodized albumen is poured on to a plate of glass to cover it with a thin even film. The plate is now allowed to dry spontaneously, after which it may be given a final heating before the fire. This hardens the albumen, and puts it in a condition for sensitizing.

This process consists in immersing the prepared side of the plate in a solution composed of nitrate of silver (50 grains), glacial acetic acid (2 drachms), and one ounce of distilled water. The plate may be exposed in the camera whilst still wet, or it may be slightly washed and again dried and exposed in its dry state.

The image is developed by gallic acid in the usual way. If, on development, the image is of

a somewhat faint colour, a small quantity of gallic acid and aceto-nitrate of silver, in equal proportions, is poured evenly over it, the tones will be deepened and force and vigour given to the picture.

When the operation has been finished by the application of the hyposulphite of soda, a negative is obtained from which positive impressions may be taken without its being varnished.

The sensitized albumenized plate, thus prepared, might be dried and kept in a dark place till wanted. Indeed dry plates produced by this method were much used by travellers and others.

After the publication of the albumen process many modifications and improvements were suggested, those of the Frenchmen, Blanquart-Evrard and Le Gray, being the most valuable.

Besides the researches which led to his method of photography on glass, St. Victor, following Becquerel, devoted much time to the subject of colour photography, and succeeded in obtaining yellows, blues, reds, and greens, all very vivid, though equally evanescent. He found it impossible to fix them. Exposed to diffused light, they quickly faded.

CHAPTER VII.

THE CAMERA AND LENSES.

Step by step with the progress of photographic chemistry went on the development of the camera. Something has already been said about the camera obscura, from which the camera of the photog-

rapher took its rise. In this, the principal apparatus used in drawing by the pencil of light, we have nothing more nor less than a dark box, to one end whereof a lens is adjusted, while to the other end is fitted a ground glass, upon which the image is cast, and by which it may be brought to a focus. When the object to be taken has thus been carefully focussed, the ground glass is removed, and what is called a dark slide or "back" inserted in its place. Exposure to the light is effected by the withdrawal of a shutter and the removing of the cap from the lens, through which all the light must pass.

These are the essential features of a camera, and if the apparatus fulfils the conditions required it is a perfect camera, though of the simplest form.

The disposition of the various parts of the camera will be easily understood by reference

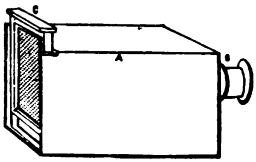

FIG. 10.

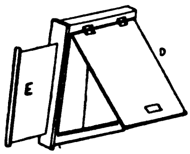

FIG. 11.

to Figs. 10 and 11, in which A represents the body, B the lens, C the ground glass focussing plate or screen, and D the dark slide or back, which is made to fit into the groove in the body A when C is withdrawn. E is the shutter which is withdrawn to allow of exposure taking place.

Each of these four primary parts of the camera has undergone various changes and modifications

of the form here represented with the progress of the art. The body of the instrument, for instance, which in the early days of photography was often made out of a cigar box and a spectacle lens, has developed into a somewhat complicated affair. In the camera in its first state there was no possibility of properly focussing an object. Then this end was attained by adopting a telescope action to the tube holding the lens, and working it by means of a rack and pinion. But this being found insufficient, the next step was to make the body of the apparatus consist of two boxes, one sliding within the other. Daguerre's camera was constructed on this plan (Fig. 12). This was a dis-

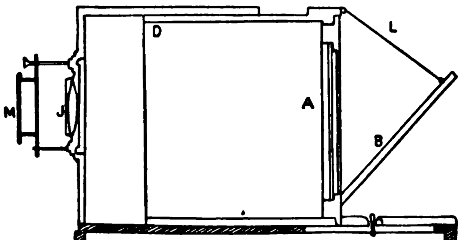

FIG. 12.—Daguerre's Camera.

tinct advance on the single box, as it permitted of more than one lens being used.

The next improvement in the body of the camera was effected by the introduction of what is known as the bellows form in 1854. The credit of this contrivance is generally given to Captain Fowkes, R.E. Its advantages were at once so apparent that it was soon almost universally adopted; and, from that time to the present, an ordinary camera is rarely seen without the bellows or concertina body.

Several attempts to produce a lighter and more portable article than the ordinary box had already been made, one of the most noteworthy of which was Ottewill's folding camera, which was very convenient for outdoor work—always a great consideration for lovers of photography.

Numerous suggestions have, from time to time, been made for adding to the camera the convenience of a developing chamber; and it is said that the instrument used by Scott Archer had some such contrivance added to it. In 1852 a camera was introduced by Mr. Newton, wherein were troughs of solution for developing the wet plates after exposure. Others seem to have turned their attention to appliances of a similar character, but with little success. Eventually the introduction of dry-plates, enabling the photographer to take a supply sufficient for the occasion when on an excursion, and developing them on his return, made the addition of a developing chamber to his camera a matter of less concern.

A convenient addition to the camera is the invention known as a double-back, which is a dark-slide holding two plates instead of one, there being one on each side. Changing boxes answer the same purpose. These are made to hold from one to two dozen plates, and are so contrived that each plate can be transferred to and from the dark-slide without exposure to the light. There are various forms of changing boxes, some very simple, others more complicated in construction. When all serve their purpose, it would be difficult to name a "best," especially as preferences enter so largely into selection.

Another arrangement of the modern camera, and one of very great importance, is the "swing-

back." This is a contrivance by which that part of the camera holding the ground-glass screen can be "swung" through a small angle, either vertically or in a horizontal direction. By the vertical movement the ground-glass is swung backwards or forwards as required, the effect being that the top of it may be placed further from the lens than the bottom, or *vice versâ*. By the horizontal or side-swing, one side of the ground-glass may be brought nearer to the lens than the other.

A similar adjustment adapted to the front of the instrument, called the rising front, enables the lens to be raised or lowered without moving the camera. In some cameras there is what is termed a swing-front as well as a swing-back, and it is occasionally a convenience that the front should be capable of slight lateral motion, although it is rarely used. It is simply an extension of the idea of the rising and falling front, and calls for no further description.

The use of the swing-back is perhaps best exemplified in the taking of a sitting figure, where, without the aid of this contrivance, it would be impossible with the lenses formerly in use to bring the knees into focus at the same time as the head. This is particularly noticeable in pictures taken with small single-lens hand cameras. A good example of the error fallen into by the operator who neglects this consideration is shown in the accompanying illustration. It is from a photograph of a lady reclining in a gondola, on her way to a ball. If she ever forgave the photographer who made of her "dainty feet" such barge-like appendages, she was surely more than mortal. The side-swing is much less used than the vertical movement, although there are occasions when it becomes extremely useful.

Some photographers affect to prefer the old-fashioned, simple cameras, without so many latter-day appliances. They undoubtedly have their advantages—one being that they do not, perhaps,

FIG. 13.

so easily get out of order. The various additions to the modern camera, however, have not been applied without reference to some distinct need, and they should not be slighted. A good instrument should be as light as possible, consistent with strength and durability, and should be as simple as possible in its working. The back of the camera should be capable of being brought up to the front for use with wide-angle lenses, and the front of being drawn out to double-

extension. It should have a rising and falling front, a reversing frame, and should swing both back and front. Such a camera is Messrs. Horn

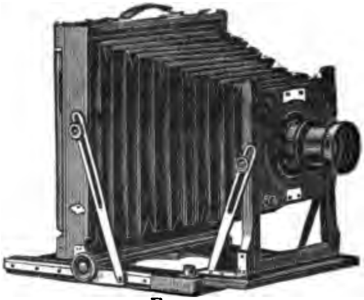

FIG. 14.

& Thornthwaite's "Whitehall," as shown in Figs. 14 and 15.

Having described the camera generally, it now becomes necessary to speak of the most important adjunct to it—the lens.

As we have seen, the lens which Porta used in his camera obscura was a plano-convex: the con-

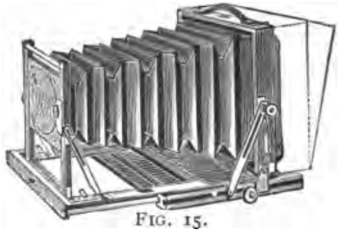

FIG. 15.

vex face of it being turned towards the ground-glass. Chevalier, a French optician, who made the cameras for Daguerre, turned the lens the

other way about, placing its flat side next the ground-glass. The image thus gained in clearness and definition, but the extent of what is called the focal plane was diminished. This fault was remedied by the use of small discs of metal, each pierced with a different-sized hole, called diaphragms, but more commonly spoken of as "stops." Andrew Ross, an English optician who turned his attention to the construction of lenses in the early days of photography, made a further advance by changing the plane surface of the lens into a concave. Another step towards the lens of to-day was taken when, in place of a single lens, combinations of lenses were adopted.

In order to make the reason for these changes clear, it will be necessary, without going into details too abstruse, to enter a little into the nature and property of lenses.

It has already been shown (page 25) that a ray

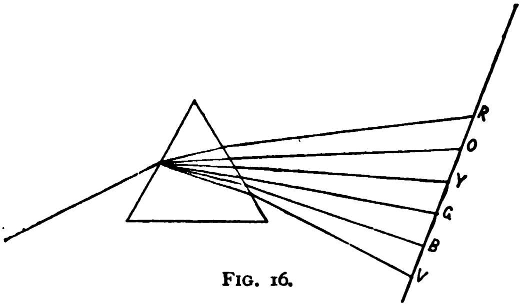

FIG. 16.

of light, in passing through a prism, is not only bent out of its course, but broken up or dispersed —that is to say, we get a band of colours, or a spectrum, which, no matter what the substance

of the prism, always occurs in the same order, namely, red, orange, yellow, green, blue, violet. In a properly-formed spectrum, we should see the band of colours crossed by dark lines, which always fall in the same place, and so enable us to fix definitely the particular coloured ray of which we desire to speak.

It will be seen from the accompanying diagram (Fig. 16) that the prism bends the pencil of light towards its base. The same thing happens if we reverse the prism, the rays being still refracted towards the base.

If we now bring the prisms together, so that the base of the one rests on the base of the other

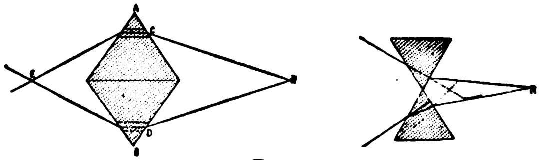

FIG. 17.

(Fig. 17), and let R be a ray of light proceeding from an object and impinging upon the prism at C and D, we shall see that they are refracted till they cross each other at E. If, on the other hand, we place the prisms the other way about, that is, apex to apex, it will be seen that the rays—still bent towards the base—can never meet (Fig. 17).

In these two arrangements of prisms we have in reality the principle of the convex or converging, and the concave or divergent lenses respectively.

As one or both of the surfaces of the lens are portions of spheres, the curved surface or sur-

faces must be struck from a centre. Thus, in Fig. 18 it will be seen that the surfaces of the lens are drawn from M and N, the line connecting which is its principal axis, as it is called. The rays of light that coincide with the principal axis of a lens do not undergo refraction, but pass through it in a perfectly straight line; all others are refracted.

Besides its principal axis, every lens possesses what is called an optical centre, which is the

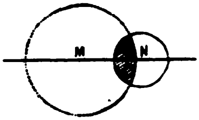

FIG. 18.

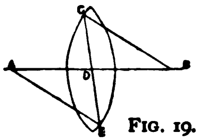

FIG. 19.

point through which pass the axis of oblique rays of light. The rule for finding this centre is to draw two parallel lines from the centre of curvature of each surface, both being oblique to the principal axis, and to connect the two points at which they cut the surface by a straight line, which must be continued till it cuts the axis; this point is the optical centre. The accompanying diagram will make this clear. Fig. 19 is a double-convex lens, in which A B are the radii of curvatures of both surfaces, the lines from which to the further surfaces are parallel to each other. From their points of impact on their respective surfaces, at C E, a connecting line is drawn; and at the point D, where this line crosses the axis, is situated the optical centre.

The centre of a plano-convex lens is situated in the convex surface of the lens, as will be seen by carrying out the above rule. When one side

of a lens is flatter than the other, the optical centre moves towards the convex surface.

In the case of a deep meniscus or periscopic glass, the optical centre is outside the lens, as will be perceived from the annexed diagram (Fig. 20), in which A B are the parallel lines

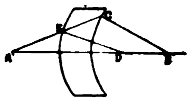

FIG. 20.

from the centres of curvature of the two surfaces, oblique to the axis; and D C a line joining the two points, continued till it cuts the axis at E, which is therefore the optical centre.

The importance of the optical centre arises from the fact that the focus of a lens is measured from this point.

CHAPTER VIII.

LENSES—*continued.*

IT has been shown that when light passes through a prism it is not only refracted, but dispersed; and as lenses are, as it were, but a collection of prisms, we see the same effect produced by them. They will at once be perceived by referring to the diagram (Fig. 21), in which A B are rays of light that, falling upon a bi-convex lens, are refracted and dispersed at the same time. As we have seen (Fig. 9) that the violet rays are bent more out of their course

than the red, it is evident that these will meet at a point nearer the lens than the red ones, or indeed than any of the others. If, therefore, we endeavour to obtain an image of the object from

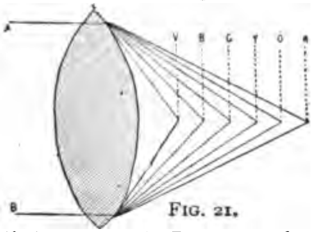

FIG. 21.

which the light rays A B proceed, and place a screen at V, we shall find that we obtain a violet image, surrounded by rings of blue, green, yellow, orange, and red; and the same thing will happen if the screen be moved back to B, G, Y, O, or R—only the circles of surrounding colour will be differently arranged.

To the human eye the brightest part of the solar spectrum is that which coincides with the yellow rays; but the rays which act with most energy upon the silver salts by which the photographic plate is sensitized lie, as we have seen (page 27), towards the other end of the coloured band. Hence, if we wish to obtain a picture by the yellow rays, the plate would be affected most by the blue or violet rays, and we should fail to secure a sharp picture, because at Y the blue and the violet rays would be represented by circles instead of by points. This peculiarity is known as non-coincidence of the visual and chemical rays, and the lens showing it is said to be non-chromatic—a defect inherent in all single lenses.

This was the great trouble of the early pho-

tographers, the distinction between chemical or actinic and visual achromatism not having been at that time properly recognised. It was for long thought that no remedy existed for this defect. Sir Isaac Newton even was of that opinion. But there is, in truth, a way out of every difficulty, and a remedy for the defect in question was discovered in the fact that, whereas all transparent substances disperse as well as refract light, they do not all disperse and refract it in the same degree. Crown and flint glass, for instance, being of different densities, vary in their qualities in this respect, the former, as a general rule, possessing less dispersing power as compared with refracting power than does flint glass. Correction of the dispersion caused by a crown glass prism therefore can be brought

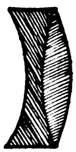

FIG. 22.

FIG. 23.

about by the use of a flint glass prism without affecting the diffraction. The same principle is of course applicable in the case of lenses. By placing a concave or negative focus lens of flint glass behind a convex or positive focus lens of crown glass (as in Figs. 22 and 23), the defects due to the breaking up of white light into its component colours is corrected.

In each case the negative focus lens is of flint glass, and its presence is due solely to the necessity of counteracting the dispersion caused by the

other lenses. Sometimes three or more lenses may be thus fixed one against another, but the principle remains the same.

It is in this way that the combination known as the achromatic (or "no colour") lens is arrived at.

Another form of aberration, which has to be taken into account and corrected in a similar way, is known as spherical. It is one which has exercised the ingenuity of lens-makers as much as that of chromatic aberration. It arises from the fact that the rays of light passing through the margin of a lens with a spherical surface meet, or, as we say, come to a focus nearer the lens than those traversing the centre. What is meant will be perceived from the diagram (Fig. 24).

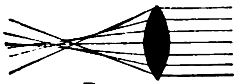

FIG. 24.

The effect of spherical aberration, if present in any marked degree in a lens, is to make it impossible to obtain a sharp image with it. Most lenses exhibit a certain amount of this defect if the glass is employed at its full aperture: that is to say, at its full width. The fault is overcome by the use of "stops."

The object of a stop or diaphragm in a lens is to reduce the diameter of its aperture, and so, as it were, to concentrate the rays of light. By so doing it serves a threefold purpose. It gives greater depth of focus by causing the converging pencil of light to fall on the plate at a more acute angle, enhances flatness of field by extending the oblique rays, and increases the defining power of

the lens by lessening its spherical aberration. By placing the diaphragm a short distance in front of the glass, the aberration is cured by the stoppage of those conflicting rays which, if allowed to pass, would interfere with the sharpness of the image.

But spherical aberration may also be rectified by making one lens compensate another. Thus when the focus of the marginal rays is nearer than that of the axial rays it is called positive spherical aberration. But concave or negative lenses lengthen marginal rays; hence by combining suitable negative and positive lenses spherical aberration may be rectified to a considerable extent. When by the choice of glass of appropriate curvatures a lens results that can be used at its full aperture without spherical aberration, it is designated "aplanatic."

But aberrations, whether chromatic or spherical, are not the only lenticular defects wherewith the photographer is troubled. There are many others. Indeed, it has been well said that the whole science of photographic lens-making consists in doing the most possible to overcome the inherent defects in lenses,* by arranging such compromises as will effect the best practical results. This necessitates the use of different forms of lenses, because in one class of work a certain fault can be put up with, or ignored, which with another sort of work would be impossible.

For instance, in a lens for portraiture the requirements are quite different to those essential in a lens for architecture or landscape. In the case of likeness-taking, if the lens gives the head

* "Optics for Photographers," by W. K. Burton.

with a fair amount of sharpness, the rest of the figure may be allowed to pass with less exactness of definition. An essential point, however, is rapidity of action. In the case of landscape, on the other hand, comparatively equal and sharp definition is required throughout the picture, whereas rapidity is of less moment. As regards architectural work, the great desideratum is that there shall be no distortion.

Distortion is of several kinds; some of these, however, may sometimes be attributed to a defect in the lens, which in reality arises from inexperience on the part of the operator, as when he plants his camera too near the object to be photographed, and in the case of a portrait has the hands or feet projected forward and represented of disproportionate magnitude. One of the most common forms of distortion justly chargeable to the lens is that known as "curvilinear distortion," the characteristic of which is that all the straight lines, except the axial ones, are shown curving either inwards or outwards. The defect arises from the circumstance that the margin of a lens refracts to a greater degree than its centre, the effect being to "condense" the outer rays into a smaller space, and so to make them converge. The fault becomes more pronounced by the use—as in the case of a single landscape objective—of the diaphragm in front. If the objective be turned round, so as to allow the light to traverse the lens before it reaches the stop, the nature of the distortion is altered. The rays then, in place of being condensed, are expanded, with the result that the marginal lines are bent outwards.

These two forms of distortion are known respectively as "outward" and "inward," or

"barrel" and "pin-cushion." Their nature will be readily understood from Figs. 25 and 26. The defect is here greatly exaggerated of course. Indeed, as a matter of fact, few lenses distort to

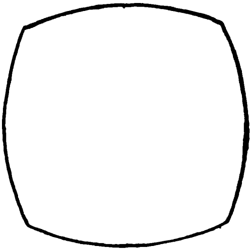

FIG. 25.

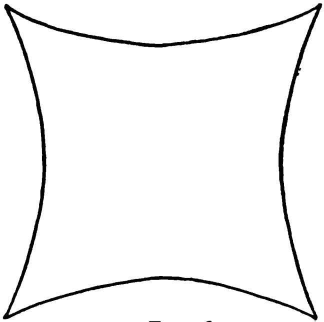

FIG. 26.

any very appreciable extent, and then only when the angle of view is a large one, and long straight lines occur at the edges of the plate. Still in the early days of photography the evil was much felt and a cure earnestly sought after. One way in which it was attempted to overcome the difficulty was by making the sensitized plates curved instead of flat. When obtained, however, they were not easy of manipulation. This caused them to be little used, and they in consequence soon dropped out of existence.

Several makers of lenses came very near the discovery of the remedy, although they appear to have missed it because—as is so often the case—of its very simplicity. Gradually, however, it began to dawn upon opticians that if a stop in front of a lens gave barrel-shaped distortion, and a stop placed behind the lens caused distortion of the

"pin-cushion" character, a diaphragm placed betwixt two lenses would have the effect of correcting both errors.

Andrew Ross appears to have been the first to put a lens on the market that came approximately near to a solution of the difficulty of curvilinear distortion in a portrait-objective of two plano-convex achromatic lenses divided by a diaphragm. His son, Thomas Ross, went a step further by substituting meniscus glasses for the plano-convex ones, not however until others had laboured in the same field with more or less success. Finally, in 1857, came the "orthoscopic" lens, the joint production of Petzval and Voigtländer. The late Mr. Traill-Taylor thus gives the history of the orthoscopic:—

"In 1840 Professor von Ettinghausen, having returned from a visit to Paris when the daguerrotype process was engaging the attention of the scientific world, remarked to Petzval (a mathematician of Vienna) that Daguerre, with whom he had been in direct intercourse, made use of a lens having a small diaphragm, by which a great loss of light ensued, and inquired if he (Petzval) could not devise a better form of lens. Acting upon this hint Petzval instituted researches, and the year following (1841) gave to Voigtländer—at that time an optician enjoying a high reputation—the formulæ for two objectives, both of them working without a diaphragm. One had a large aperture and a short focus, and gave great concentration of light over a large area; the other had a longer focus, and was capable of covering a large field. The former was the now well-known and universally used portrait lens, the other being the orthoscopic, which was

allowed to lie *perdu* for several years afterwards."

The orthoscopic ("correct seeing") was considered a great advance on the lenses of those days, when the single achromatic was the only lens in use for landscapes, and gave an increase of aperture with improved flatness of field. But it was a mistake to suppose that it was entirely without distortion, although such as it had was of the opposite form to what had theretofore been common.

The orthoscopic consists of a plano-convex, or nearly flat achromatic meniscus, together with a back lens of bi-concave crown glass, joined to a flint-glass meniscus (Fig. 27).

The portrait objective of Petzval, above referred to, is a combination consisting of two

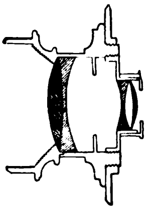

FIG. 27.

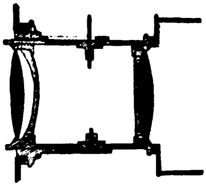

FIG. 28.

achromatic lenses placed some distance apart. The front one is a plano-convex, or else of so slightly meniscus shape as to appear almost plane. It is composed of a crown-glass bi-convex joined to a plano-convex flint lens. The back lens is a bi-convex composed of a double-convex crown and a concave-convex of flint glass. These lenses are usually mounted so as not to touch one another (Fig. 28).

Before quitting this subject of distortion it is necessary to mention another very important aberration, one which figures very largely in all recent photographic literature, that, namely, known as astigmatism (a word derived from the Greek, and meaning not coming to a point). "If," says Zentmayer, "we focus a well-defined round object, situated in the axis of a lens of wide aperture, on a screen, we shall find the image round; even if we move the screen in and out of the focus the image will only become less sharp; but if we turn the lens sideways, so as to get the image of the same object formed by pencils oblique to the axis, then we shall observe that it is no longer possible to form a sharp image of the object, and by moving the screen in and out of the focus the image appears elongated, horizontally or vertically."

Astigmatism is therefore a serious fault for a lens to possess, if present in any marked degree. It is usual to find it in lenses corrected for great flatness of field, as it is called, although the defect is seldom wholly absent from any lens. One of the great aims of modern lens-makers, therefore, has been to produce non-astigmatic combinations. Into the formation of the lenses of which these are composed, we find entering one of those new discoveries which have played so considerable a part in the evolution and development of photography. I refer to the new kind of glass known as Jena glass.

Until of recent years flint and crown glass were the substances exclusively employed for the fabrication of objectives. The first named is a silicate of potassium and of lead; the second is a silicate of potassium and of chalk. Flint

glass strongly disperses and refracts the rays of light, while crown glass possesses but a feeble power to disperse and refract. Although united they compensate each other's defects to some extent, that is, they render it possible to vary the refractive power of lenses, yet they do not allow of an alteration of the dispersive power in a like manner.

In 1842 a French glass manufacturer named Grimaud had the idea of substituting the borates for the silicates in the making of glass. There was no demand for the new thing however, and the use of boric acid was abandoned almost as soon as indicated. For one thing it was recognised that there was a lack of stability about the new material. However, what in France proved to be a non-marketable substance, met with better success abroad. Turned to advantage for optical glasses by Herr Schott of Jena, it ere long became known far and wide as Jena glass.

With it Dr. Abbe soon found that it was possible to make lenses without the presence of secondary spots. Zeiss, the optician, undertook to construct objectives for the microscope on the lines indicated by Abbe. The result was such as to delight microscopists. It need hardly be said that this first success led to others. From the microscope to the photographic objective was but a step, and it was quickly taken, Voigtländer, Steinheil, Harnack, Darlot, and Berthiot, all turning their attention to the new glass. For the objectives thus constituted was claimed a great amplitude and clearness of field, together with considerable diminution in the length of exposure.

Nor was this all. For Dr. Rudolph, taking his

stand on the one hand upon a general principle established as regards uranophotography, in 1885, by Dr. Hugo Schrœder, and on the other, adopting a plan proposed by Dr. Abbe, he was able to give to the optician Zeiss the elements for the construction of an objective composed of two simple meniscus lenses of crown glass, between which was placed a lens of smaller diameter and of triple correction. This central portion of the objective was little more than a plate of glass with parallel surfaces, and had but little share in the lenticular action of the combination. Nevertheless it played a most important part in the whole, admirably correcting all the chromatic and spherical aberrations of the objective.

This combination was given the name of Apochromatic Triplet with central correction. The correcting lens being composed of the baryte flint glass of Jena, the achromatism is corrected for three colours in place of two, and the secondary image totally disappears. It is further claimed for the combination that it gives an image entirely free from distortion as well as from the central flare spot. Moreover, the field of view is flat, and the astigmatism still possible from the oblique rays does not exceed that obtained with good aplanatic lenses of corresponding aperture.

So much it seemed necessary to say about the Jena glass and the lenses made from it. It need hardly be added that while the new material is still on its trial, so to speak, it already bids fair to supplant the time-honoured flint glass of English manufacture, as well as to revolutionise the whole art of lens-making.

The above particulars, and the triplet of J. H. Dallmeyer, will give an idea of the way in which

combinations came to be built up, in order to secure achromatism and non-distortion. The latter was at one time very highly thought of by photographers, and still holds a distinguished position amongst objectives (Fig. 29).

These examples will serve to illustrate the principles of photographic lens construction. It

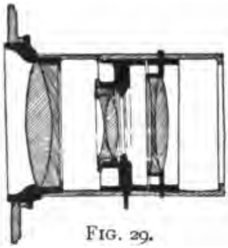

FIG. 29.

should, however, be noted that one disadvantage attending these combinations is that the more the surfaces are multiplied the greater is the loss of light. Some makers have sought to overcome the difficulty by cementing the separate glasses together, and to a certain extent they have succeeded. The disadvantage, however, attendant on this loss of light has become of much less importance since the introduction of quick plates than it was in the old portrait days.

The subject of lenses is such a large one that one might extend these remarks to almost any length. Sufficient has been said, however, to give the reader an insight into the depth of scientific research which has been necessary on the optical side to bring photography to its present standpoint. One would like to add

something about the different makers of lenses; but space will not permit.

It need hardly be said that a person who takes up photography seriously can hardly get along with a simple objective. Although the beginner may do so, and, indeed, will find it advisable to confine his attention to one lens—say a rapid rectilinear, or a good single lens—until he has thoroughly mastered it. For general work—landscape, groups, and portraiture—an achromatic, with an aperture of f/10 or f/11 (*i. e.*, $\frac{1}{10}$ or $\frac{1}{11}$ of the focus) is a good lens to select. For landscape or sea-views only a wide angle lens is the best These are single objectives.

In doublets (Fig. 30), as a combination of two is called, one of the best for general purposes,

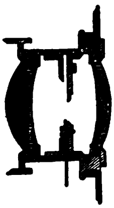

FIG. 30.

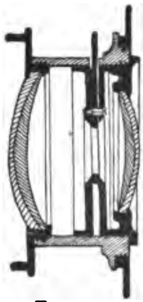

FIG. 31.

for rapid or instantaneous views, for copying, enlarging, etc., is the rapid rectilinear of, say f/8. Where an objective for photographing interiors and for architectural work in confined situations is required, a wide-angle rectilinear of double the above aperture might be chosen.

One of the most useful wide-angle lenses is that of Dallmeyer, of which an illustration is given (Fig. 31). Although Dallmeyer made these lenses for the most part as here shown, that is, with a front lens of larger diameter and longer focus than that of the back lens, other makers generally give the two combinations the same diameter.

One advantage of possessing a wide-angle, double rapid rectilinear, or portrait lens is that the half combination may be turned to advantage as a single landscape lens of a narrower angle and of about twice the focal length of the whole. A useful doublet specially for portraits is one of f/3 or f/4. Of course if a half combination be used in this way the length of exposure has to be considerably increased. For some years past manufacturers have been turning their attention to the making of lenses in series, so that a photographer might go out with a complete battery, so to speak, suitable for every kind of work, and capable of use in the one moment. By careful selection, a man may thus have, neatly secured in a pocket-case, every focus, either singly or in combination, for which his camera is adopted. Such sets of lenses, if carefully worked out, are extremely useful and cannot be too highly recommended.

CHAPTER IX.

THE INTRODUCTION OF COLLODION.

THE next important advance in the chemical department of photography, after the introduction of albumen on glass plates, was the inven-

tion of the collodion process. Collodion is a viscid compound composed of soluble pyroxyline dissolved in ether, to which alcohol is added. When poured upon a plate of glass it runs freely over the surface, and, the ether and alcohol evaporating, the collodion is left behind in the form of a tough translucent film.

M. Le Gray appears to have been the first to suggest the employment of collodion as a vehicle for holding the sensitive salts. In a book published in 1847, and translated into English in the following year, he says: "I have just discovered a process upon glass by hypofluoric acid, the fluoride of potassium and soda dissolved in alcohol, forty degrees Fahr., mixed with sulphuric ether, and afterwards saturated with collodion; I afterwards react with nitrate of silver, and thus obtain proofs in the camera in five seconds in the shade. I develop the image with a very weak solution of sulphate of iron, and fix with hyposulphite of soda." A similar hint as to the value of collodion was made about the same time by Robert J. Bingham, an assistant of Faraday. But it is to Frederick Scott-Archer that the world is indebted for the practical introduction of this method of photography.

Scott-Archer was a sculptor, and he appears to have taken up photography in order that he might preserve records of his works. How he came to turn his attention to collodion is not known; but towards the end of 1850 he had so far succeeded in the working out of his process that he made it known to some of his friends, and amongst others to Mr. P. W. Fry, the photographer, from whom in particular he received much assistance, and to whom much is due for its successful application.

6

The results obtained by collodion were so greatly in advance of anything that had hitherto been achieved in practical photography that it may be said to have established the art on its present basis. It almost immediately came into very general use, and many adepts in chemical manipulation gave much time and attention to improve the methods of making the compound, and to discovering the best ways of using it.

One method of preparing the collodion is by soaking clean cotton-wool in nitrate of potash. When thoroughly soaked, the excess of nitrate of potash is removed, and a quantity of sulphuric acid, to which a small quantity of nitric acid has been added, poured over it. The next operation is to take out the cotton and wash it thoroughly in running water, after which it is freed from water by squeezing, and then dried. It is now the well-known gun-cotton or pyroxyline, and may be dissolved in sulphuric ether in the following proportions:—

Sulphuric ether . .	18 fluid ounces.
Alcohol	6 drachms.
Pyroxyline . . .	30 grains.
Solution of ammonia .	5 drops.

The solution obtained is collodion, and when some soluble iodide, and a little potassium bromide have been added, it is ready for use.

In the early days of collodion many of the leading photographers prepared their own, and had their own ways of doing it. To say nothing of its dangers, it was a tedious process, and caused the early photographers an amount of toil and trouble of which the men of to-day have but little conception.

When poured upon a plate of glass collodion

freely runs over the surface. Two or three minutes is sufficient for the film to set. When coated the plate was immersed in a bath of silver nitrate for about a minute, during which time silver iodide was formed in the pores of the collodion. The plate was now ready for exposure in the camera. Development was usually effected by means of pyrogallic acid, the power of which in bringing out the latent image Archer claimed to have been first made known by him, and the picture was fixed by soaking the plate in hyposulphite of soda, though at a later period cyanide of potassium was generally preferred, because of acting more quickly; a thorough cleansing in running water followed. After the plate had been allowed time to dry, the last and completing process, before the negative was handed to the printer, was to protect the film from abrasion by a coat of varnish.

Collodion gradually pushed its way, and by 1854 its use had superseded almost all other methods with the general photographer; for by this time photography had become a profession. With collodion, too, the amateur was able to take the subject up, and during the next few years photography became very popular with people who love a hobby, and who, in the case of photography, did a great deal towards perfecting its methods.

By this time, however, the inventor of the process, who at first appears to have thought so little of it that he did not protect it by a patent, was in his grave. He had made so little out of his invention that his family were left almost destitute. A timely subscription, however, and a government pension of £50 per annum, saved the children from want.

The almost inestimable value of collodion was hardly established before the many shortcomings attending its use began to be perceived, and attempts made to remedy them. One drawback connected with its employment was the necessity that the glass plates coated with the sensitized collodion should be exposed in the camera while wet, and, further, that the exposed plates must be developed before the surface had had time to dry. For this reason the wet collodion process, though suitable enough for the studio, was ill-adapted for outdoor work, while for travellers its use was almost an impossibility. If it was desired to take a photograph of an interior, where, on account of the dim light, a long exposure was requisite, the surface of the plate had time to dry before the task was accomplished, the result being that the plate was spoiled, for the simple reason that the silver iodide crystallises when dried in contact with the nitrate of silver, and so makes a spotty negative. In cold weather the silver nitrate solution was too slow to work.

Many attempts, and a great many suggestions, to overcome these and other defects in regard to the wet collodion process were made during the years immediately following its introduction. It is not necessary, however, to enter into them here. Suffice it to say, that ere long various methods were devised for keeping the prepared plates moist for a certain time. Nitrate of zinc, and then nitrate of magnesia were used for this purpose, and found to answer for a week or more by preventing crystallisation. A solution of honey, or grape-sugar, was employed for the same purpose, with some success. In lieu of anything better, these and similar processes were made use of

for some years; but a stepping-stone to a new and important advance was laid when Dr. J. M. Taupenot, a French scientist, made public a method wherein a solution of iodized albumen was poured over the collodionized and sensitized plate, which was then allowed to dry. The plate was then dipped a second time in a bath of silver nitrate, and again washed and dried. "This was," says Mr. W. J. Harrison,* "the first dry-plate process of practical utility." The philosophy of the process was that by its means the superabundance of the salt was washed away, and so crystallisation obviated.

The process was published in *La Lumière* in 1855, and was soon after made known in England, where it was very popular for some time. The plates would keep for six or eight weeks; but the great drawback to the process was that it was slow. Taupenot's method undoubtedly established the value of the dry-plate, and every effort was now made to improve it. After the publication of Dr. Taupenot's collodio-albumen process in 1855, "every few months," says Harrison, "saw the announcement of some new substance or other, wherewith the sensitive surface of a collodion plate might be covered, so as to enable it to be dried and kept ready for use."

Dr. Norris of Birmingham appears to have been the first to make dry-plates a commercial success. He took out a patent for his process in 1856, and for ten years they had considerable vogue. According to his own description of his process, the film, after having produced in it the sensitive iodide of silver, "is immersed in a solu-

* "History of Photography."

tion of gum arabic, or of dextrine, starch, gelatine, albumen, gum tragacanth, vegetable mucilage, caseine, gluten, or other such like substances, that will, by occupying the pores of the collodion film, prevent its condensation on drying, and retain it in a sensitive and pervious state; the films are then dried, and are ready for exposure to light, or may be kept for any length of time and used as desired." The plates thus prepared are said to have been nearly as rapid as wet collodion plates, and it is thought by some that the maker had "discovered the superior sensitiveness of bromide over iodide of silver," and that the rapidity of the plates was due to the use of the former.

A number of other dry-plate processes came into use during the same period, although they were all, without exception, slow as compared with the wet-plates. One of the most interesting of these was that first used by Major C. Russell, who, having employed gallic or pyro-gallic acid for increasing the keeping powers and sensitiveness of dry-plates, was thence induced to try tannin, the substance from which those acids are derived, with the result that he found it better than them. Another valuable process was that devised by Captain Abney, and known as the "albumen-beer process," which was used with success by the expeditions sent out in 1874 to study the transit of Venus. The secret of it lay in the use of a mixture of albumen and flat beer, with which the sensitized plate was given a wash.

Important, however, as these developments were at the time, they proved but stepping-stones to better things. One of the most striking facts connected with photography, indeed, is the rapid-

ity with which it has passed from stage to stage. It speaks much for the intelligence of the men who successively took hold of it, either in its scientific or its art aspects, that within the century it has been developed from its first ineffectual beginnings to the position it now occupies as the hand-maiden of all the arts and sister of every science. No branch of science has leapt from callow youth to virile strength with such rapidity, and even yet it seems barely to have passed its adolescence.

Collodion emulsion was the next step onward. Very soon after the introduction of collodion it was foreseen that the next advance would be to a method whereby the silver nitrate bath could be eliminated. So early as 1853 a French photographer named Gaudin put forth the idea that "the whole future of photography seemed to require a sensitive collodion, which could be preserved in a flask and poured, when required, upon glass or paper; and by the use of which, either at once or after the lapse of time, positive or negative pictures could be obtained."

This put succinctly in words a notion that must have been floating in many minds. Indeed before this statement appeared in print combinations intended to meet that end had been announced; but neither these nor Gaudin's "photogene," as he called it, a compound of nitrate of silver dissolved in hot alcohol and added to collodion, met the need. And it was not until the latter part of 1864 that a really effective emulsion was devised. This was the production of Messrs. Sayce & Bolton of Liverpool, who, by adding nitrate of silver to a bromized collodion, developed silver bromide in the collodion. Plates coated

with this concoction were given a wash of tannin and then dried.

This first rough draft, so to speak, was quickly followed by improvements until, some ten years after its first introduction, an emulsion was produced composed of pure silver salt and collodion, which could be kept in bottles for years. All that was necessary when the emulsion was required was to melt it by placing the bottle in hot water, and then to coat the plates with it and dry them. The "Beechey Dry-Plates," very popular for many years, and still in use, were made from a preparation very similar to the Sayce & Bolton emulsion.

CHAPTER X.

THE GELATINE-BROMIDE PROCESS—ROLLER SLIDES —FILM PHOTOGRAPHY—THE HAND CAMERA.

NOTWITHSTANDING that the collodion process, particularly in its wet state, rendered such important services to photography, it is to-day almost wholly a thing of the past. The later generation of photographers, indeed, know little or nothing about it, and probably the majority would not know how to use it if they wished.

As early as 1850 Poitevin—after Daguerre and the two Niépces perhaps the most fertile of the earlier French experimenters in photography, and one to whom the art-science owes a great deal—suggested the use of gelatine as a vehicle in place of collodion, the dangerous nature of which, apart from other drawbacks, was always felt to be a disadvantage. He did no more, however, than

throw out the hint; and it remained for others, either independently or acting upon his suggestion, to prosecute the line of research thus indicated.

Many busy brains and cunning hands were soon at work on the problem; although it was not until 1871 that Dr. Maddox of Southampton succeeded where others had failed. In the month of September of that year he published in the *British Journal of Photography* a note on the production of an emulsion, the chief ingredients of which were gelatine and bromide of silver. Thirty grains of gelatine were swelled in cold water, and then dissolved by the application of heat, four drachms of pure water and two drops of *aqua regia* being added. Into this solution were then cast eight grains of cadmium bromide and fifteen grains of nitrate of silver, the result being a fine milky emulsion of silver bromide.

Plates that had been given a thin coating of this emulsion and then dried, upon being exposed beneath a negative, showed a faint but clear picture when developed with a solution of pyrogallic acid.

Maddox's experiments were not completely successful, the reason being, as would appear, at least in part, the presence of nitric acid (caused by the *aqua regia*), which, acting as a restrainer, made the plates slow. Had he carried his investigations a little further he would doubtless have been able to overcome the defects in his process; but all the available time he had at his disposal appears to have been taken up with photo-microscopy, and he had perforce to relinquish to others the line of research thus set afoot. Publishing his results, therefore, he left the matter for others

to think over and work out to a more complete and satisfactory issue, remarking that "so far as can be judged, the process seems quite worth more carefully conducted experiments, and, if found advantageous, adds another handle to the photographer's wheel."

Amongst others who took the hint thus thrown out and worked at the problem involved, were Kermetter abroad and Burgess and Kennett in England, all of whom produced a commercial article, though without deriving much benefit therefrom. The fact is they just failed to reach complete success. The difficulty with Burgess's emulsion was that it was apt to decompose at anything like a high temperature. The presence of soluble salts was the trouble. These Kennett endeavoured to remove, and he patented a compound of "an aqueous solution of gelatine, together with a bromide, chloride, or iodide, and nitrate of silver," which "is cleared of certain salts," formed during the mixing, and then dried.

Both Burgess and Kennett prepared dry-plates, but commercially they were not a success—partly, no doubt, because they were a little before their time. Older photographers, who remember their introduction, will often recount, with an amused smile, how much they were beyond them. Their training in the old methods had been such that they could not understand their rapidity. They would spoil plate after plate, simply because of their inability to give them a sufficiently quick exposure.

Doubtless, the plates, too, were somewhat to blame. The fact is, that the time was not yet ripe for the perfect emulsion, because our knowledge of silver bromide was not sufficiently complete.

Perhaps it is worth while to note here that bromine—a deep reddish-brown liquid, fuming strongly at common temperatures, and found in sea-water combined with magnesium—was only discovered in 1826, and that it was not until the publication of the researches of the Belgian chemist Stas in regard to chloride and bromide of silver that the world was made acquainted with the fact that the sensitiveness of bromine to light is greatly intensified by the application of heat.

It was the realisation of this fact by Mr. Charles Bennett, an amateur photographer of London, that finally solved the problem of a gelatine emulsion. By boiling his different solutions at a temperature of 90 degrees, he succeeded in making an emulsion that enabled him to obtain results which were a surprise to all who saw them, not merely on account of the quality of the pictures themselves, but from the rapidity with which they were taken. He very generously made public his process. This was in the early part of 1878, and, within a few weeks of the publication thereof, gelatine dry-plates had been manufactured and put on the market by several leading firms of photographic material manufacturers.

The effect produced by the introduction of the gelatine process was second to nothing that had gone before in the history of photography. It caused a complete revolution in the art, and, necessarily, in much of the material and apparatus whereby its results were achieved *—one

* An "old hand" reminds me that one of the not least important effects produced by the introduction of dry-plates was that of allowing of clean hands.

of the minor, though still important, changes produced, being a saving in cameras, which were so rotted and deteriorated by the wet plates. These may be treated together, seeing that the changes that were brought about in the form and interior mechanism of cameras, in order to meet the increased rapidity of exposure, and by the augmented resources of the art in regard to picture supports, are but branches of the same subject.

The "new things" in photography come so quickly one after another that we are apt to forget the sensation of yesterday in the novelty of to-day. Yet it is but a few years since the photographic world enjoyed more than a nine-days' wonder in what is known as the roller-slide, with its accompanying paper or film support.

The history of these things, like most else in photography, is one of gradual evolution; one idea being thrown out here and another there—the two then lying in wait for the development of a third. As early as 1854, we have the first germ of the roller-slide in a patent taken out by Spencer & Melhuish. Though crude enough in its general mechanism, the *idée mère* was present in the two rollers within the frame of the camera, one of which held the supply of sensitized paper, while the other received it as soon as it had been exposed, length by length, and received its picture. In this way, a succession of pictures could be taken on a long strip of sensitive paper. Although this invention appears to have had some success—a qualified success as an ingenious novelty—it was unquestionably before its time.

About the same period, several other workers were exercising their wits in the like direction,

and notably Captain Barr in India. But it was reserved for Warnerke to give the world what was in reality the first practical roller-slide. His own description of the contrivance—published in 1875—gives its principal components as "two rollers on which the sensitive film is wound," which afford "room for one hundred plates." By this he means that, "before the film is attached to the roller, it is divided into sections corresponding with the size of the plates by black lines drawn in pencil or otherwise." Through the instrumentality of a darkened glass plate in front, in the place corresponding with the focussing surface, the sensitive film was guided in its progress from one roller to the other, and secured in its proper position. The film was wound from one roller to the other by means of metallic heads to the rollers. Exposure was obtained by a sliding shutter, and in the shutter was a tiny orange-glass window, for the purpose of observing the black lines on the film, and so securing the sections in proper position.

The roller-slide was only made possible with the introduction, or rather the revival, of sensitive film supported, not on glass, but on a flexible material. As we have seen, Fox-Talbot made use of paper for his negatives; and although paper was superseded by glass when the collodion process became popular, yet photographers were not slow to recognise that such a brittle substance as glass possesses serious disadvantages. Investigators endeavoured to find or to produce some material which, while possessing the transparency of glass, would be lighter and of a less brittle nature. Amongst others, Woodbury turned his attention to this problem,

and in 1876 succeeded in manufacturing such a compound from Canada-balsam, collodion, and castor-oil.

This mixture, after being spread on a sheet of glass and allowed to dry, was coated with a sensitive emulsion and again allowed to dry. It was then taken from its glass support and cut into lengths for use in the camera. Although the inventor did not go beyond this, he threw out the idea that the film, being perfectly flexible, and hence capable of use in long bands, might, by means of rollers, be submitted in suitable lengths to the luminous image, and thus the inconvenience of changing plates be dispensed with by the turning of a handle outside the camera.

Warnerke took up this idea, and, though on the first appearance of his roller-slide he used paper coated with collodion emulsion, on the introduction of the more highly sensitive emulsion, which would not permit of the use of orange-glass windows, a further stage in the evolution towards the instantaneous camera was reached.

Besides the advantages of lightness and non-fragility, film photography possesses another superiority to glass, and that is its freedom from halation—the term applied to a certain blurring of the image caused mainly by reflection from the back surface of the glass support. In glass negatives it is shown by an encroachment of the light portions upon the dark, as, for instance, in taking a window, where there would be an invasion of light upon what should be dark all round the edge.

The rapidity of the dry-plates and the film is such that cameras specially constructed for the

purpose can be held in the hand during the operation of exposure. Much ingenuity has of late years been given to the development of the capabilities of the camera in connection with the use of dry-plates. The forms the "dark-box" has taken under the new requirements are almost uncountable. For small-sized photographs various contrivances have been adopted whereby the camera itself becomes a storage for plates, a simple mechanical arrangement permitting the exposed plate to be transferred to the back, while another takes its place. The "magazine camera," as it is called, possesses certain undeniable advantages, though it is outdone by the roller-slide camera when the film used in the latter can be thoroughly relied on, which, unfortunately, is not always the case.

While, therefore, for ease and the rapidity with which successive exposures can be made and views taken, nothing comes up to the hand-camera with the roller-slide and film, for sure work the magazine camera is, on the whole, preferable. It forms no part of the scheme of this work to enter into the respective merits of cameras; there are many excellent ones in the market; but for hand as well as tripod use, Newman & Guardia's instruments cannot easily be beaten. They are provided with good lenses, and have all the special features of a first-class tripod camera—vertical and horizontal rising fount, extension to double or triple the normal focus of the lens, iris diaphragm, hand and pneumatic releases, etc. (see Figs. 32 and 33).

Another development which has arisen out of the extreme sensitiveness of the dry-plates is what are known as flash-light pictures. These are pho-

tographs taken by means of the almost instantaneous flash of light produced by scattering powdered

FIG. 32.—Hand camera, closed.

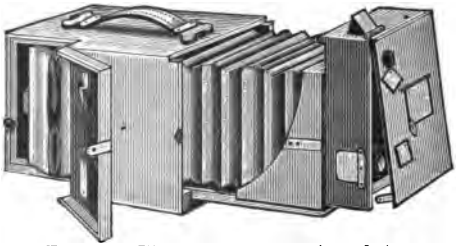

FIG. 33.—The same, open, to show fittings.

magnesium in the flame of a lamp—of which there are many specially contrived for the purpose. There is generally a receptacle attached for holding the magnesium powder, which is carried into the flame by means of a pneumatic ball and tube. Very effective pictures of groups and of children are taken in this way. Exposure is generally managed by pressure of the pneumatic ball, which puffs the powder into the flame, so that the simultaneity of the two operations is as nearly as possible perfect.

CHAPTER XI.

PHOTOGRAPHIC PRINTING PROCESSES.

It will be remembered that Niépce's attention was first turned to the problem of fixing the image of the camera obscura by his experiments in lithographic printing; and his earliest successes in photography were in the reproduction of engravings. In other words, they were experiments in photo-printing. Fox-Talbot went a step still further, and his calotype may be said to have been the first effective printing process in which photography is the primary agent. Although improvements have been made in the method, it has continued to be employed to some extent to the present time. One of the chief modifications of the original process was the addition of albumen to give a surface to the print. The albumen fills the pores of the paper, and keeps the sensitive salt of silver, subsequently added, upon the surface.

The credit of the introduction of albumenised paper is usually given to Fox-Talbot, but it seems to belong more properly to Le Gray. Gelatine is now much used in place of albumen.

Since the first publication of Fox-Talbot's method, the number of printing processes gradually evolved out of the photographic art is very great. To deal with them in anything like an exhaustive manner would require a considerable volume. It need hardly be said therefore that only a brief general account can be given of them here.

Photographic printing processes are of two

sorts, direct and mechanical. The simplest example of the direct process was that practised by Thomas Wedgwood in 1795 and by Davy in 1802, though they were unable to fix the image obtained. Their method, as well as that of Fox-Talbot, was a process of silver printing—a process which still largely holds the field in photographic printing.

At the present time silver printing is done for the most part upon fully prepared and sensitized papers. This, however, was not always the case; and even now many photographers sensitize their own paper, even if they do not do the albumenising themselves. The prepared, though unsensitized, paper is floated on a solution of silver nitrate and then dried. The silvered surface is exposed to the action of light in a printing frame, the length of the exposure being timed to the brightness of the light and the character of the negative. Toning is effected by a solution of chloride of gold, though sometimes a platinum chloride (chloro-platinite of potassium) is used. After fixing with hyposulphite of soda, the picture needs to be quickly, though thoroughly, washed. The papers chiefly used for silver printing are of foreign make, and are most commonly prepared with gelatine emulsions of chloride of silver.

The impressions obtained from silver printing can hardly be exceeded in beauty; but there is one drawback to their enjoyment, and that is the doubts that have been thrown on their durability. On account of this tendency of silver prints to fade, efforts were early directed to the discovery of a more permanent method.

Various suggestions were thrown out, and

many experiments were made, but the first method discovered that promised real permanency of impression was that of Swan, who introduced his carbon process in 1864. He was, however, but an improver on the ideas of others. As early as 1839 Mungo Ponton made known the fact that under certain conditions bichromate of potash is sensitive to light. In other words, it was found that paper steeped in the bichromate, and then dried, changed its colour when exposed to the light. Another fact that subsequently appeared was that light does not merely alter the composition of the bichromate but that it oxidizes the gelatine of the paper. Upon this discovery is based the much-used carbon process—perhaps the best known of all methods for obtaining durable prints. Gelatine is not the only substance that thus becomes insoluble when exposed to light in conjunction with bichromate of potash, or other chromium salts, starch, gum, and albumen, amongst other like compounds, being similarly affected.

When gelatine is soaked in cold water it absorbs the water and swells; then, if the water is heated, it melts. If bichromate of potash be added to the cold water it also is absorbed. By this absorption of the bichromate the gelatine has been so altered that, on being dried and exposed to the light until the stain caused by the chemical is changed in colour, it no longer possesses the quality of swelling in cold water or dissolving in hot. The action of the light upon the bichromated gelatine has been such as to render it insoluble.

The importance of this discovery as the germ of a practical printing process seems to have

struck many minds about the same time, including Poitevin and Beauregard, and several devoted themselves to the task of working it out. It was not done all at once, however, and the various processes that were the result have not all proved equally successful. But to this principle of chemically treated gelatine we owe the "Autotype" or "carbon" process, sometimes styled the pigmented gelatine process. It is one of the most important methods known, and upon it are based the Collotype, the Woodburytype, and even some forms of photo-zinco engraving and photogravure.

There were, however, many difficulties to be overcome before the "carbon" became a practical process. Into these it is not necessary to enter here further than to state that, after many experiments, Swan perfected his method even to the getting of the long desiderated "half-tone." In its final form gelatine was dissolved in water, with which bichromate of potash was mixed; then finely powdered carbon was added by way of pigment. Paper was coated with the mixture and dried, and was then ready for exposure under negatives.

There being no visible picture, as in a silver or iron print, an actinometer had to be used to time the exposure. The print was now coated with an india-rubber solution and placed upon a sheet of paper similarly treated. After having been dried and passed through a press the whole was soaked in warm water, both the paper and the soluble portions of the gelatine being then removable, and nothing being left but the image. This was necessarily in relief, the depth or shallowness thereof being proportionate to the gradations of the negative, the half-tone being adequately rep-

resented. The film was now spread upon the paper that was to be its final support, albumen serving for cement.

A valuable improvement was made in this process by J. R. Johnson in 1869. He found that when the Autotype tissue had been exposed it only required to be soaked in cold water and then placed on a waterproof support in order to adhere by atmospheric pressure. This discovery proved so important that it made of the carbon process a practical method of printing. Johnson used rigid supports; but Sawyer went a step further by introducing flexible supports in the form of paper varnished and so rendered water-proof.

Meanwhile, during the gradual development of the Autotype process, another permanent method, although one of more restricted application, had been brought out (1857). This was the powder process of Messieurs Salmon and Garnier, based on the fact that "ferrous salt resulting from ferric citrate is more hygroscopic than the ferric citrate itself." * Herschel, as will be seen, had thoroughly tested the relative sensitiveness of the different salts of iron, finding that the double citrate of ammonia was more readily acted upon by light than any other, next to it coming the double oxalate of iron and potassium. Upon these properties he built up the processes of printing already referred to, and concerning which more will have to be said later.

In the Salmon and Garnier process paper covered with ferric citrate is exposed under a transparent positive, and then brushed over with a fine dark pigment like plumbago. In the parts not

* "Treatise on Photography."—Abney.

acted upon by the light the citrate of iron is sticky, or "tacky," as is the photographic phrase, and so causes the powder to adhere to it, while the parts which the light has effected become so dry that the pigment obtains no hold. The result is improved when some preparation of sugar, gum, or other sticky substance is mixed with the citrate. The process is faulty as regards half-tones; but for the reproduction of engravings it is, in a modified form, still occasionally used with advantage. The same method has been employed, with some variations of procedure, for transferring the photographic image or picture to glass or porcelain in the form of enamel, and with very fine results.

Another method which calls for mention is that based on the sensitiveness of uranium salts, discovered by Gehlen in 1804. Niépce St. Victor and J. C. Burnett seem both to have turned their attention to this metal as a possible means to a printing process about the same time; albeit Harrison * accords priority to the Englishman (1857–8). By this method paper is floated on a solution of uranic citrate, and when dry exposed beneath a negative in the usual way. Development takes place in a solution of nitrate of silver or chloride of gold; a very fine image in metallic silver or metallic gold, as the case may be, being the result.

A variation in the uranium process was introduced by Wothly, and hence called Wothlytype, in 1864. He employed uranic nitrate with other salts in collodion, and appears to have been the first to employ collodin on paper for positive printing. Starched paper was coated with the

* "History of Photography."

collodionised nitrate, and was printed until the picture came out as a bluish black, being then intensified by means of gold. Although a company was started to work the process, it did not prove a success. About the same time a method of positive printing was discovered by Mr. G. Wharton Simpson, general manager of the Great Western Railway, in which collodion was used for holding silver chloride in suspension. By means of the film thus produced very good results were obtained both on opal glass and paper, but the process seems never to have become popular in Great Britain.

A method closely allied to the carbon process has recently attracted considerable attention both in this country and abroad, and bids fair to become rather popular, at least where expense is no object. This is the one known as the bichromated gum process or photo-aquatint, which is based on the principle, above referred to, that gum or any colloid substance impregnated with a chromic salt becomes insoluble in proportion as it has been affected by the action of light. The paper is treated with a sensitive mixture of this description, to which plumbago or any colouring matter may be added. Development is effected by water alone. As there is no visible image, exposure has to be timed by the actinometer.

The process places in the hands of an artist a power of developing or suppressing parts of the latent image which enables him to produce by purely photographic means any effect he may wish to secure, from absolute obliteration to varying degrees of half-tone and shadow. It is a method, of course, whereof only the most skilful can avail themselves successfully. A particular

development of the gum bichromate process is that of the late M. Artigue, whose *papier velours* is a distinct advance on anything of the kind yet produced.

Although its chief value is for monochrome, the method is much used on the Continent, particularly in Vienna, for printing in colours. Almost as many colours as desired may be employed. The process, however, is extremely difficult and laborious, necessitating successive printings or exposures, together with extremely careful registration, and notwithstanding the resulting polychrome is often very fine, it is doubtful whether it repays for the ingenuity and patience demanded for its production.

Next to the carbon and allied processes the most valuable is perhaps the invention made by Mr. W. Willis, and patented by him in 1873. It is based on the quality possessed by platinum of being deposited from some of its chemical preparations in an extremely fine black powder when brought in contact with one of the iron salts acted upon by light. Herschel had previously explained a method of obtaining prints in platinum, and others had worked in the same direction, but nothing satisfactory was effected until Willis turned his attention to the subject. In its latest development—patented improvements having been brought out in 1878 and 1880—the platinotype paper is sensitized by means of a mixture of chloro-platinite of potassium and ferric oxalate. When exposed under a negative the ferric salt is reduced to the ferrous state wherever the light has reached it. A faint image is the result. By now "floating the exposed paper on a solution of neutral potassium oxalate, which is a solution of

the ferrous oxalate, the platinum salt in contact with it is reduced to the metallic state, and an image is thus built up."* The prints, which are extremely delicate and beautiful in colour, are fixed by immersion in dilute hydrochloric acid.

There is no question as to the permanency of platinotype, which, moreover, besides its engraving-like colour, possesses the advantage of extreme simplicity of manipulation. The process is fully described in a little work by Pizzighelli and Hubl, to whom it is indebted for some improvements. By an invention of the former the developer is added to the sensitizing solution applied to the paper, and development takes place simultaneously with the printing by means of atmospheric influences. For the platinum process a dead or "matt" surfaced paper is used, which gives a much more engraving-like appearance to the prints than can be obtained on the glossy surface of gelatine or albumen-faced papers. To this fact is largely attributable the popularity of that process.

Another method, known as the Blue Printing process, though based on the action of light on ferrous salts, is much older than the platinotype. It is the Cyanotype of Sir John Herschel. Twenty-four grains of ammonio-citrate of iron is dissolved in an ounce of water; a given quantity of this is mixed with an equal quantity of a solution composed of forty-eight grains of ferri-cyanide of potassium to an ounce of water, and with it one side of a sheet of white paper is washed by means of a sponge. The paper thus sensitized is used for the most part in the copying of plans

* Abney.

and drawings which appear in white lines on a blue ground. Pictures from photographic negatives can be taken in the same way, and recently for a short time small landscapes printed by this method became rather popular.

There are other processes in use amongst photographers which are more or less adaptations or modifications of those already mentioned. Of such is the iodide of silver on paper (Fox-Talbot's calotype without the oiling of the paper), much used at one time on account of the pictures it gave after brief exposure. Another method still used to some extent for certain descriptions of enlarging work is a transparency on wet collodion films, which are transferred from glass to paper. Both these processes were eventually superseded by the employment of the gelatino-bromide and the gelatino-chloride papers. Swan patented the first-named process in 1879; but W. T. Morgan appears to have been the first to put a gelatino-bromide paper on the market, and it soon became extensively used, both for direct enlargement and contact printing.

The gelatino-chloride of silver paper was introduced by Marion & Company in 1884, and soon became popular, partly by reason of its cheapness. It was turned to good account in connection with Urie's automatic printing machine, by means of which some two hundred copies an hour could be printed. The paper gives warm and varied hues, but generally needs toning.

John Urie, of Glasgow, does not appear to have been the first to devise a method of automatic printing. He was anticipated in the United States by Fontayne, and he has had imitators in Germany and France. In England, however, the

idea has been developed to an extent and in a direction hitherto apparently undreamed of in the ingenious photo-printing machine of W. Friese-Greene, which, as will be seen from a description of the process in the next chapter, bids fair to revolutionise the whole process of letter-press printing.

CHAPTER XII.

PHOTOGRAPHY AND LETTER-PRESS PRINTING.

COMMENTING upon a camera devised by Mr. Friese-Greene for the rapid taking of consecutive photographic views, a photographic journal, in February, 1890, remarked that "the chief value of the machine, or of a modification thereof, may hereafter be found to be in the direction not contemplated by the inventors—at least they have said nothing on this point—namely, in the printing of positives for book illustration, for in positive printing through a negative the amount of light can be made vastly to exceed that present in the photographic street views, so that the limit of speed, especially with improved machines as yet unborn, is at present beyond calculation. One can imagine the possibility of a practically endless band of paper being covered with some sensitive preparation as it unrolls, then passing on to the exposure platform, and afterwards into developing and fixing baths. At the present time exposing a negative on a travelling band three thousand times in five minutes would not be bad work."

These lines were no sooner read by the inven-

tor of the camera referred to than he saw the feasibility of the idea which the editor had thrown out, and the thing began to take shape in his mind. A few months later he had constructed a model which fully answered to his expectation, and the invention was patented (1891). About the same time (October 29, 1890), this model was exhibited in the Literary and Scientific Institution of Bath by the inventor, who also read a paper upon it, which, amongst other things, contained a forecast of the use to which the invention might be turned. Speaking of the effect the original idea had upon his mind, Mr. Greene said: "My blood was fired with enthusiasm, for I thought of taking a scene in Hyde Park or in the City, where the ceaseless stream of life is never ending, by the machine camera one day, and producing in the course of a few hours a paper which could be delivered to the public showing, true to nature, all the movements of life, or anything that might be of interest which was photographed at the time. . . . A well-known person's photograph, with his letter, could be copied by photography and put in print much more quickly than you could set up the type for the letter, leave alone a block—which would take days—for the likeness, and then not be so perfect as it would come out being printed by light alone, for you could not equal the texture and detail by the block process that you could obtain by the other."

When this forecast was made, the invention had not gone beyond the rough model stage. But by that model was produced a long band of photographs printed from half-plates, with gas as the illuminant, the exposure being almost instantaneous. The invention having gone so far, and

been protected by patent, the matter was allowed to rest. Many persons saw the model, and one or two were convinced that there was in it the germ of a wonder-working machine—to be produced some day. It was not, however, until some time in 1896 that anything was done towards putting the invention to a thoroughly practical test. When that was done—which was rendered possible through the intervention of a capitalist—it was found to be possible to make great improvements in the machine, and to obtain the end aimed at in various ways; so much so, indeed, that it was deemed advisable to take out fresh patents.

As already said, the first experiments were made with the original model; but, as this allowed of the printing upon one side of the paper only, and from half-plate negatives, it was, at an early stage of the experiments, decided to construct a machine large enough to print eight pages of the *Strand Magazine*, namely, four on the one side of the paper and four on the other.

The machine, as will be seen from the illustration (Fig. 34), consists of a box for the printing process, and a number of tanks or troughs to receive the developing, fixing, and finishing solutions. The box consists of two separated chambers for containing the negatives, the first chamber containing the negatives to be printed on the upper side of the paper, and the second chamber containing those to be impressed on the under side of the paper. Each chamber constitutes practically a dark room, with a sliding shutter to admit the light, the light being contained in a separate compartment called the light box, divided from the chamber proper by the shutter. The light is

supplied by incandescent electric lamps, and may be diffused or reflected from a mirror.

The negatives are firmly fixed in a frame, and the frames, fitted with grooves, are made to slide

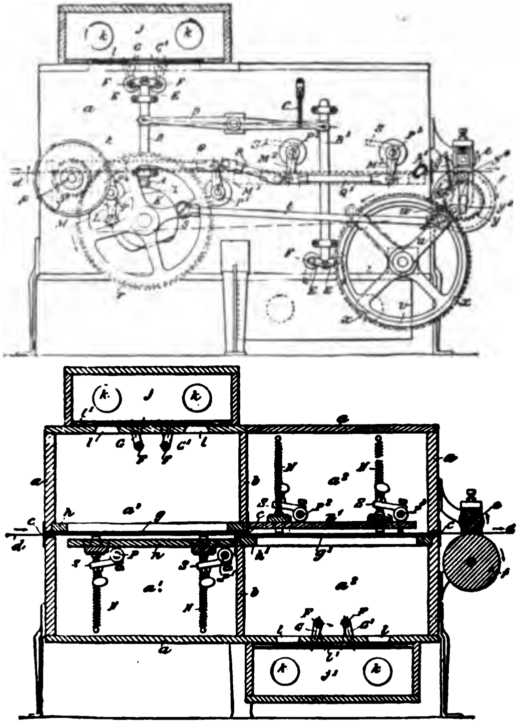

FIG. 34.

in and out for the purpose of changing the negatives, etc. When in position the negatives are

in their respective dark chambers, that for printing the upper surface of the paper just above, that for printing the under surface just below, the central line of the machine along which the sensitized paper is carried. Immediately under the paper in the first chamber, and immediately over it in the second, is a platen or pressing-plate, faced with soft felt, which, when exposure is made, presses the paper upon the under side of the negative.

The paper to be printed on is contained upon a roller, and is either already sensitized, or it may be sensitized on its way into the machine by passing through a trough charged with the necessary emulsion. It goes into the machine through a slot, and, as soon as it has filled the two chambers by the action of the machine, the apertures in the light boxes open, while simultaneously the platens press the paper against the negatives, steadying it, and thus the exposure is made.

The instant the exposure is made, the respective apertures close, the pressure of the platens is removed, and the printed portion of the paper is carried forward, giving place to a fresh, unprinted portion. This intermittent motion of the machine proper, which is obtained by means of a pawl, is then repeated, and, with each forward movement of the paper, a portion of the sensitized surface is exposed to the light, first on the upper and then on the under side. As soon as the paper, thus printed upon, emerges from the printing box through a slot, the intermittent motion is converted into a continuous one, which is maintained uniformly while the paper is being carried successively, by means of glass rollers, through the tanks containing the developing, fixing, and

clearing solutions, and so finally into an enclosed chamber or box filled with hot air or exhaust for drying.

From the description it will be understood that every section of the band of paper equivalent in length to an intermittent feed is first printed on the upper face, and then on the lower face; and that, while one section is being printed from the negative in the first chamber, the next following section is being printed from the negative in the second chamber. When it is desired to print on one side of the sensitized paper only, one or other of the chambers is not supplied with a negative, and of course the electric lamps of the respective light box are shut off.

An important consideration connected with the working of the machine is that both the exposure and the development are being carried on at the same time, so that the operator who is controlling the machine is able to see at a glance if the picture or printing is not coming out as it should. If there is over-exposure, he can easily, by an electrical resistance register, adjust the light to the negative. In the same way he can modify or strengthen the developer to the needs of the case.

A smaller machine, for purely photographic purposes, is made single for printing upon one side of the sensitized paper only. These can be adapted for use either with an incandescent lamp or with an ordinary oil lamp. When the latter is employed, there is no difficulty in adjusting the light to the quality of the negative.

The negatives employed may be either negatives produced directly by photography, or they may be photographs of pages of letter-press printing; or a negative may be used in which the two

are combined—an ordinary photograph, presenting a view or a person, to which a letter-press description has been added—or other combinations may be made; even an author's own MS. might be printed from.

By a later development of the machine, which need not be explained here, further than to say that the intermittent up-and-down motion is replaced by a cylindrical arc (similar to that of the rotary printing machine), a much higher rate of speed can be obtained than by the platen press.

In further development of his idea, the inventor has patented a machine whereby he does away with the use of ordinary type, employing in their place a sort of typewriter (worked by keys), which yields its impression by means of photography.

It will be seen that the new photographic printing machine is very simple in construction, and it is believed that by it the cost of printing will be greatly reduced, as well as the quality of it greatly improved, especially as regards the printing of illustrated books, newspapers, &c. There are no complicated movements requiring expensive and heavy machinery; and, indeed, so little friction is there that the machine is almost noiseless. As regards its artistic value, those who have seen prints produced by it affirm that, as regards its variety and delicacy of tones, and the uniform quality of impressions, it outdoes anything that has gone before. Whether it will in the long-run sustain this high praise or not, time will show; but, in any case, it must be acknowledged to be a striking development of photography—that wonder-worker of the sciences.

CHAPTER XIII.

PHOTO-BLOCK PRINTING.

A NUMBER of processes have been devised for applying photography to the production of blocks or plates, from which impressions may be taken by purely mechanical methods. These processes are of three kinds. They consist of blocks or printing surfaces in which (1) the parts intended to show up in print are sunk, cut, or etched below the even surface. These are known as intaglio plates or blocks; or else (2) the printing surface is a film so treated that various parts thereof differ in their capacity for taking or rejecting ink, the picture or design in ink being afterwards transferred to paper by contact; or (3) the portions to be printed stand out like type, receive ink, and are printed in the ordinary manner of letter-press, the half-tone in such cases being produced in some sort of stipple or grain, as in various kinds of engraving.

It will be seen that these three varieties of photo-mechanical printing have affinities respectively with the methods of copper-plate, lithographic and letter-press printing.

In all photo-printing processes the great difficulty has been the production of half-tone. To secure two tones, that is, black and white, as in pen and ink drawing, is a simple enough matter; but it becomes altogether a different affair when the attempt is made to seize all the gradations of tone, all the subtle shades of chiaroscuro, intervening betwixt the deep shadow and broad light, as seen in nature, and reproduced in a good photograph.

Not all the processes hereafter to be described succeed in overcoming this difficulty; perhaps indeed only one of them is completely successful. That process is the one known as Woodburytype, from the name of the inventor, Walter B. Woodbury, who took out his first patent for the method in 1866. Roughly speaking, the process consists in obtaining an intaglio impression of the image which it is required to copy. The mould thus secured is filled in with transparent coloured ink, which, transferred to paper, makes the picture. The deepest portions of the mould naturally take the most ink, and represent the darkest shadows, while the shallowest portions take the least, and represent the most delicate tones; so that all the gradations of tint are truly exhibited.

Others had worked at such a process before the actual inventor, and Woodbury himself was not in the outset completely successful. The first step in the process is to obtain an image in relief by means of a film of bichromated gelatine. This is dried, exposed under a negative, and developed as in the Autotype process, the result being an image in considerable relief. The unexposed portions of the film are left soluble, while the other parts are rendered insoluble to depths corresponding to the intensity of the light.

The relief thus obtained is now covered with lead, and the two are pressed together in a hydraulic press which, strange to say, produces a reverse or mould of the image in the soft metal without injuring the gelatine relief. The intaglio mould thus produced is placed in a press of simple construction, ink in the form of a pigmented gelatine is poured upon it, and a strongly-sized sheet of paper laid over it. A platen of

perfectly flat glass is now brought down upon the paper and mould, and held tightly in position by a clutch (Fig. 35). The pressure forces out all the superfluous solution, while that in the

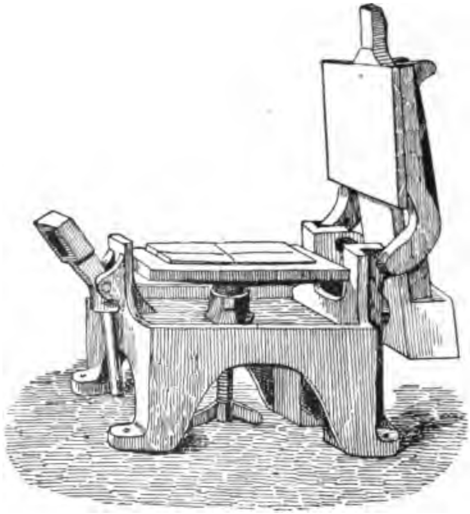

FIG. 35.

mould adheres to the paper. When the gelatine has had time to set, the platen is raised and the paper removed. Then, to finish off the print, it is placed in a solution of alum which hardens the gelatine.

Another process which was successfully worked out by the author of the above method is that known as Stannotype, or printing from a tin surface. It is thus described by the inventor: "A positive is first made from the negative—pref-

erably by the carbon process. From this carbon or other transparency a negative is made, also in carbon; but in this case the tissue possesses much more body and much less colour, so as to obtain a certain amount of relief. This (gelatine) relief negative is then coated with a thin india-rubber varnish. A piece of tinfoil is laid over it, and the whole passed through a pair of india-rubber rollers—a species of mangle in fact. We have now a printing mould ready for placing in the press and printing from in gelatinous ink." Although the Stannotype process does not give the beautiful pictures obtained from Woodbury's first method, it yields results of a very high quality.

Another modification of the Woodbury process is one much used for photo-engraving. The relief is stamped into lead or type metal as in Woodburytype with this difference—that the bichromated gelatine has had powdered glass mixed with it, and this produces a grain. From the lead block a copper plate is obtained by double electroplating, and printing is done as in copperplate. The excellent photogravures produced by the Goupil process are said to be obtained by a modification of the above method. A variation of Woodbury's invention was introduced in 1880 by Major Woodhouse; but it does not appear to offer any special advantages.

The only process which differs materially from Woodbury's or the still earlier one of Fox-Talbot seems to be that brought out by Obernetter, which is thus described by Burton:* "A posi-

* "Practical Guide to Photographic and Photo-Mechanical Printing Processes."

tive is produced on a film of gelatino-bromide of silver very rich in the silver salt. The silver of the developed and fixed image is converted into chloride of silver by the action of the mixture of perchloride of iron and chromic acid. The film is then wetted and brought into contact with the surface of the copper-plate, which it etches, the chlorine leaving the chloride of silver to combine with the copper-forming chloride of copper, which is soluble in water."

Although Fox-Talbot's engraving process (patented in 1852) did not, as regards results, come up to those described above, excellent prints were obtained by it, and it is believed that many of the secret processes practised here and on the Continent are but modifications of his photoglyphy. The process consists in printing the negative on a bichromated gelatine film, washing away the unaltered gelatine, and making an electrotype from it. He even proposed to obtain half-tone by impressing on the gelatine film, prior to exposure under the negative, "the image of a piece of folded gauze or other suitable material" —the means still largely used for obtaining gradations of tone.

In later years Talbot hit upon the idea of improving his method by adopting the use of powdered resin for the production of grain. He does not appear to have been very successful in its application; but the idea was worked out with good effect in a process based upon his and patented long after by Clic, the main difference between the two being that, whereas Talbot proposed to spread the resin over the gelatine relief, the former applied it in the form of a fine powder on the surface of the copper-plate, using heat to

make it adhere.* The process is much used both in England and abroad.

The name of Poitevin has been frequently mentioned in these pages. To him photography owes many original ideas. He was one of the first to experiment with bichromatised gelatine. In 1855 he discovered that gelatine so treated, after exposure to light, will "take" greasy ink, while it repels water. Upon this principle he based a process of photo-lithography, which, as Collotype in England and Lichtdrück in Germany, has become one of the most useful forms of photo-mechanical printing.

The method of working the collotype process is as follows: A sheet of glass is coated with a film of bichromated gelatine. When dry it is exposed under a negative, the result being a faint image. On being washed in cold water, those parts of the plate that have not been acted upon by the light swell up. Between the extreme blacks and whites of the print there is a complete gradation of tones produced by a reticulation or grain in the gelatine. The process of printing from a collotype plate is the same as in lithography; that is to say, it is damped, inked, covered with a sheet of paper, and so passed through the press.

There have been a number of modifications of the collotype process, only a few of which have proved commercially successful. They vary in minor details only, and need not detain us here. In 1861, however, Col. De C. Scott, R.E., and Sir Henry James brought out a process which proposed to overcome one defect in collotype print-

* Burton.

ing, namely, the limited number of impressions which could be taken from a plate. To this they transferred the map or plan—it being designed chiefly for the copying of line subjects—to zinc or stone, from which an indefinite number of copies could be printed. Others applied themselves to the same idea with useful results. Captain Abney made some advances on his predecessors in the process to which he gave the name of papyrotype, and upon his method J. Husband, R.E., based a procedure for securing a half-tone by means of soluble crystals embedded in the bichromated gelatine. A full description of the process is given by Burton.*

We now come to the third method of applying photography to the production of printing surfaces, that, namely, for making blocks to be used with type in ordinary letter-press printing. This is the form in which photo-engraving comes most under the popular eye, being employed not only by the newspapers for their often crude illustrations, but also in the highest class magazines, in which it has almost wholly superseded wood-engraving, as well as in book-work. The process is one of relief, and while it is an easy matter to reproduce line subjects in this way, it is quite another thing to secure half-tone. For a long time all attempts to meet this difficulty were in vain; but of late years better success has attended the efforts of experimenters.

The earliest and most thoughtful workers in this branch of photo-engraving were Poitevin and Pretch. Woodbury also worked at the production of relief blocks for typographic printing,

* "Practical Guide to Photography," etc.

using a screen of gauze or network to produce a grained impression; but in this respect he seems to have been more successful in giving out ideas for others to develop, than in perfecting a workable process himself. Two methods, both with more or less resemblance to Woodbury's, if not actually based on it, take the lead at the present time. These are the Ives and the Meissenbach processes.

The best known in England is the Meissenbach process, which, after having been worked by Messrs. Bullock and Swan for a number of years, was patented by Meissenbach in 1882. This process is thus described: "A transparent plate is etched or stippled in parallel lines. A transparent positive is made of the object, the two plates are joined, preferably face to face, and from the combined plates a definite negative is photographed in the ordinary way. In order to cross-hatch and break the lines of the shading, the hatched or stippled plate may be shifted once or twice during the production of the negative. The photographic negative thus obtained may be applied either directly to a zinc plate, or a lithographic transfer may first be made in the usual manner, and the plate subsequently bitten by acid to form a block in relief."

The Ives process is a very original one in so far as the production of half-tone is concerned, and its excellent results may be seen in many of the American magazines, which until very recently left the English periodicals far behind in regard to their illustrations. Of late, however, the English magazines have been gaining ground very rapidly. Burton thus describes the general principles of the method: "The process depends on the pres-

ence of a half-tone relief on a surface more or less compressible, and consisting of a series of slight eminences forming a grain, as, for example, paper having a surface something like bookbinders' cloth. The eminences are flattened out in proportion to the height of the relief, and if by any means the *flattened* portions be inked, the result is a grain representing a half-tone on account of the greater size of the dots or grains in the darker than in the lighter parts. In fact, in the deepest shadows the eminences are entirely flattened, giving an even black tone; in the brightest lights they are not touched at all." The image thus produced was transferred to a zinc block, which was then etched.

An improvement upon his first method was subsequently introduced by the inventor, in the substitution, in place of the grained paper, of an india-rubber pad with V-shaped grooves in it, and a plaster of paris reproduction of the Woodbury relief for the relief itself.

A number of other processes might be referred to, including that of Zuccato, a very ingenious one, having some resemblance to the last named, but they are all more or less alike in principle and need not detain us here.

For the reproduction of line drawings there are many different processes, including the bitumen method invented by Niépce, and employed by St. Victor to copy engravings, which, with but little modification, is still used. Another simple method is to get a proof of a line drawing on stone in transfer ink, and transfer it to the polished surface of a zinc plate in the ordinary lithographic manner. After the transfer the plate is slightly wetted, and the lines well inked; they are

then dusted with powdered bitumen, and the plate immersed in an acid bath, in which the uncovered parts are quickly etched away. When other than transfers are to be dealt with, such as pen and ink drawings, engravings, or any other subjects in line, the picture is reduced to the required size by photography. It is then treated as for photo-lithography, transferred to stone, retransferred to zinc, and so proceeded with as above.

A more direct, and, at the same time, sharper process is one in which bichromated albumen is employed. The zinc plate is thinly and evenly coated with albumen in which a quantity of bichromate of potash has been dissolved. A strongly photographed negative, taken in reverse from the drawing, is then put on the plate and exposed. Development is effected with cold water, albumen being, unlike gelatine, thus rendered soluble. The method is remarkable for the clean sharp lines it gives. The plate is etched in the usual way. There are also several gelatine processes which are similar in general procedure to the above. Zinc is generally employed because it is cheap, and because it is readily bitten into by the acid; but sometimes copper is had recourse to for finer and more expensive work.

In the finer and more artistic forms of photogravure England seems so have been left almost entirely behind, as in so many other departments where exceptional knowledge of technique is required, by the French and the Germans; nearly all the best reproductions of large pictures by photogravure being done at Paris or Berlin. It is to be hoped, however, that now that the technical schools are turning their attention to pho-

tography, and to the various ways in which it may be applied to the industrial arts, photogravure will not be entirely lost sight of.

CHAPTER XIV.

RECENT DISCOVERIES AND APPLICATIONS.

It would be difficult to name a branch of science—hardly a department of industry—that has not benefited from photography. During the sixty years that have elapsed since the announcement of the joint discovery of Niépce, Daguerre, and Fox-Talbot, light as chemist has not only broadened and deepened our sight, but has revealed to us wonder after wonder, secret after secret. More marvels, indeed, have been the result of the penetrating eye of photography than perhaps of all the sciences combined during the previous hundred years.

Something has already been said anent the triumphs it has achieved in registering "the belted zone of the spectrum," and supplying a perfect method of obtaining visible images of the actinic rays. It has given us pictures also of the moon, the stars, and the nebulæ. Eclipses it has recorded for us, and by its aid we have obtained drawings of the transit of Venus. The sun's corona has been depicted for us by means of its magic pencil, while, in like manner, it is giving us day by day the history of the spots on the great luminary's disc which are supposed to mark the birth and development of volcanic movements in the body of the orb that are not with-

out their physical and moral effects upon our daily lives.

One of the latest astronomical triumphs of photography is perhaps Professor J. E. Keeley's "spectroscopic proof of the meteoric constitution of Saturn's rings." All students of astronomy are acquainted with Maxwell's mathematical demonstration that the rings of Saturn consist of an immense number of separate small satellites revolving round the planet in circular orbits. These separate bodies are so small that it is hardly likely we shall ever be able to observe them as such in the telescope, and it seemed probable that we should have to be satisfied with the mathematical demonstration of their existence. It is needless in this place to go into a description of Professor Keeley's method of working. Suffice it to say that by means of photography he was able to clearly establish the meteoric constitution of Saturn's rings. Moreover, in addition, his photographs give us "the data for estimating the period of rotation of the planet, the mean period of rotation of the rings, and the rate of motion of the whole system in the line of sight due to the revolution of the planet round the sun." *

At all the leading observatories throughout the world the aid of photography is being used for the mapping out of the heavens; and to its delicate retina has been revealed myriads of stars that were beyond the ken of the most powerful magnifying glasses. This may seem strange when it is considered that astro-photography can only work by means of the telescope. But it

* "Photography Annual," 1896.

ceases to be surprising when we bear in mind that any light or other energy—albeit invisible and impalpable to the senses—capable of affecting the sensitive surface of a photographic plate exerts a cumulative action. Thus, while an astronomical watcher at the first moment of observation may see a hundred stars, as he continues to gaze his eye becomes fatigued and he beholds fewer and fewer. But the photographic plate, in place of tiring, goes on augmenting impressions, until at the end of half-an-hour it may have seen a thousand or more times as many, though it began by noting only the same number.

Analogous to these triumphs in the vastitude of space are the achievements of photography in the realm of the infinitely small. By the aid of photo-micography we have been enabled to take the portraits, so to speak, of disease-bearing germs, and for the better study of their structures to throw them, by means of the optical lantern, greatly enlarged upon screens. In the same way all the various parts and tissues of our bodies may be, and are, studied by the aid of this handmaid of the sciences. These are, for photography, long established achievements; but there is another department of anatomical science in which the triumphs of the art are so recent that the novelty and wonder of them are still fresh in the public mind.

Most persons will remember the sensation caused throughout the civilised world by the announcement that a German scientist, Professor Röntgen of Würzburg, had succeeded in photographing the bones of the hand through its covering of flesh by means of the rays proceeding from a spherical glass tube or bulb.

Some twenty or more years ago, it should be explained, Hittorf and Goldstein, two German physicists, observed that in tubes of this description the light visible to the eye, going from one electrode to the other, was due to the imperfection of the vacuum in the tubes, and that the more carefully the vacuum was made the weaker the light became, until it totally disappeared when the vacuum was rendered perfect. They noticed, further, that at this moment the glass of the tube became fluorescent, and from the circumstance they inferred that the fluorescence was caused by the oscillating discharges of invisible rays, of which the cathode was the point of origin.

Such spherical tubes—known from the circumstance that Professor Crookes was the first in England to experiment with them as Crookes'

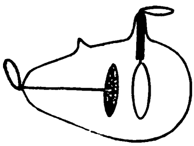

FIG. 36.—Crookes' Tube.

tubes—were the instruments by which the New Photography was first observed. In the early part of 1894 Lenard, at Bonn, showed that it was possible to secure shadows of objects through optically opaque substances, and to obtain an impression of these shadows on photographic plates which could afterwards be developed and fixed by ordinary photographic methods. So modestly was the fact announced, however, in the midst of other and more striking novelties, that

even those who read Lenard's paper when published had well-nigh forgotten that such "shadowgraphs" had been obtained by him, until their attention was called afresh to the subject by the announcement of Röntgen's more sensational discovery.

It was towards the end of 1895 that, experimenting with the spherical tube, Röntgen observed that a hand held betwixt a bulb electrically charged and a sensitized plate did not completely arrest all the cathode rays. He found that the soft parts were transparent, while the bone remained opaque, and that, in a word, it was possible, by means of a Crookes' tube, to obtain an outline of the skeleton of the hand upon a substance ordinarily sensitive to the light. Röntgen gave to these invisible and penetrating radiations the name of X-rays. Within a few weeks of their first announcement there was scarcely a physical laboratory in the world but was the scene of experiments that were soon extending the range of the new Photography.

In these experiments there is no question of a camera, or even of a lens, so that they are photographic only in so far as a sensitive surface is changed by the action of light, and as the result an image of the object is left upon the plate, and made permanent in the usual way.

Most persons are now familiar with the photographs obtained by means of the Röntgen radiations, which, at first an object of curiosity only, were soon found to be of great use in surgery by rendering it possible to discover the exact position of a foreign body, like a bullet, a needle, or other metallic substance in the system, or to examine a fracture or malformation.

But the importance of Professor Röntgen's accidental discovery—for it appears in the first instance to have been a happy chance—does not rest with its applicability in surgery. It opens up questions of enormous magnitude. Several theories have been advanced to account for the phenomena. One is that the X-rays may be ultra-violet light with vibrations about a million times greater than ordinary light; another, and

FIG. 37.—Portion of Hand with Needle embedded in the Ball of the Thumb. (*From a Photograph by Prof. Hicks, F. R. S.*)

the most sensational, is the supposition that the Röntgen radiations may be the missing longitudinal waves in the ether—a theory which, if true, would open up a department of physics as large as those of light, sound, electricity, or even the theory of gravitation itself. Whatever hypothesis may prove to be the right one, there is no question that the phenomena involved in the new Photography have "brought us face to face with

facts which would only a short while ago have been considered improbable, if not impossible." * Thus a new realm for scientific exploration has been disclosed, and no one knows whither it may tend or what fresh surprises it may have in store for us.

Hardly less of a surprise than the X-rays to the general public was the development of photography in the form of the Kinetoscope, the Cinematograph, the Theatrograph, etc., but in general popularly referred to as "animated photography." The idea was not new; it had long been known as the wheel-of-life or the zootrope. Marey made use of it in his researches touching animal locomotion. Muybridge carried the matter a step further by means of a battery of cameras. Meanwhile the highly sensitized film was introduced, making it possible to secure an image of a moving object in the smallest fraction of a second.

The moment was ripe for a further advance in regard to the photographing of objects in action, and W. Friese-Greene appears to have been the first in the field with his patent for an apparatus, half camera, half optical lantern, whereby he proposed (1) to take a series of instantaneous photographs of moving scenes upon a long band, and (2) to throw them, enlarged, upon a screen, whereon, by means of a handle, the successive pictures would be moved so rapidly as to give the appearance of life.

But, although Friese-Greene's original patent was taken out in 1889, he was anticipated as regards the actual production of his invention in public by Edison's Kinetoscope. This may be

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* *Strand Magazine*, July, 1896.

called the animated photograph in little. It was soon followed by the Cinematograph of M. Lumière of Paris, whose exhibitions of this form of photographic realism in London caused no small surprise in the early part of 1896. Previously, however, Mr. Birt Acres had exhibited similar animated pictures before the Royal Photographic Society by means of a specially designed optical lantern. At first the lifelikeness and substantiality, so to speak, of these living pictures were greatly marred by vibrations and a general jerkiness of motion ; but modifications and improvements in the apparatus soon eliminated these imperfections, and the verisimilitude to the actual moving scene became almost perfect.

FIG. 38.—Animatograph. From the "Practical Photographer."

The possibilities that this form of photography opens up are almost endless, and we may ere long expect the "living picture" to be rendered useful not merely in providing popular amusement and entertainment but for instruction in schools and in numberless other ways.

Among the more notable things connected with photog-

raphy of late years has been the great advance made in regard to developers. Much has been said about these in the foregoing pages; but it will be necessary to say a few further words about them. To many operators a developer is simply a chemical compound which brings out the latent image when applied to the exposed plate. But in truth the developer is more than that, and the sooner anyone who takes up the study of photography frees his mind from such an idea the better—if, that is, he would be an artist as well as a wielder of the camera.

Captain Abney has said that the development of the latent photographic image is both an art and a science in one, and anyone who has had much experience with the developing bath will readily endorse the statement. In short, development is to the photographer much what the brush is to the painter, or the chisel to the sculptor: it gives him the power of drawing out his picture from the hiding-place on the plate, and infusing life or lifelikeness into it.

To the eye of course the exposed plate presents nothing by which it may be distinguished from the unexposed one. The impression it has received through the chemical action of the light is said to be latent; and it is for the combined science and art of the photographer to bring this to view by reducing the silver in those parts that have been acted upon by the light to the metallic state. This he is enabled to do by means of the various developers at his disposal.

There are so many that the question as to which developer it would be best to employ in a given case is not an easy one. The true craftsman, however, does not quarrel with the wealth

of implements or material at his command, but rather sets about making himself thoroughly acquainted with them one by one, and having satisfied himself as to the best for his purpose for the time being lays the others aside.

As already shown, the developers in more general use are pyrogallic acid and ferrous oxalate, to which may be added hydroquinone. These are usually found enough for all ordinary requirements. The last few years, however, have seen a number of new developers brought to light, and all of them have their special uses, and, it may be added, their special admirers.

Of the eikonogens, amidols, metols, rodinals, etc., it is not necessary to speak in any great detail. Are not their constitution and qualifications set forth in all the photographic journals and manuals?

Eikonogen, which was introduced in 1889 (though discovered by Professor Meldola in 1881), is accounted a good developer for quick exposures. It gives fine detail, and a soft, albeit somewhat thin, black picture, with delicate half-tones. For density (that is, opacity), the solution should be strong in eikonogen, with potash carbonate added as an accelerator; while citric acid is recommended in preference to bromide for preventing fog and correcting over-exposure. Some hold it specially useful to portrait negatives.

Amidol acts with great rapidity, especially when dissolved in a solution of sodium sulphite, which acts as an accelerator. It yields excellent detail and good density, and is a specially useful developer for "snap-shots" and lantern-slides. Mr. J. A. Wilson considers amidol superior to

any other developer for bromide paper. Metol gives a fine soft negative, is rapid in action, and capable of bringing out good detail. With potash carbonate as an accelerator, fair density is obtainable. Metol is peculiarly useful for plates that have received a minimum of exposure, and is, perhaps, along with amidol, better qualified for hand-camera work than for time-exposures, wherein the image is produced with so much force that development is not so easily kept in hand as with a more deliberate agent like pyrogallic acid.

Hydroquinone is intimately allied with pyrogallic acid—or, briefly, in photographic parlance, "pyro"—in chemical composition. It was suggested by Captain Abney, the *doyen* of photographic experts, in 1880, in place of pyrogallic acid; and gradually, year by year, it has gone on superseding that developer, especially for films—experience showing that the negatives developed by it not only show more detail, but a crisper and cleaner image. It is somewhat slower, however, than pyro, while it gives greater density than either amidol or metol. Indeed, some object to it because of what they consider its tendency to yield harsh negatives. This is a fault which is easily overcome by careful management, using a dilute solution and proceeding with deliberation. It shows less tendency to fog than most developers, and is, without doubt, capable of producing excellent results.

Glycin, another of the newer developing agents, acts more like pyro than like either amidol or metol. It is very slow in action, and, like hydroquinone, has a tendency to hardness if not kept well under control. Bringing out the image very gradually, and gathering opacity with the appear-

ance of the details, glycin is specially well adapted for copying maps and drawings, and for photo-mechanical work generally. It has also been recommended for very brief exposures, as, for instance, those varying from a hundredth to a thousandth of a second. The colour of the negative is a clear greyish black, and there is great freedom from veiling. With glycin, bromide of potassium acts as a restrainer.

Rodinal is a very concentrated form of para-amidophenol, with which is combined sodium sulphite and caustic alkali. It is a good all-round developer, very well adapted for hand-camera work, and, generally, for getting as much as possible out of a plate. Seeing that it does not act as an agent to fog the picture, development may be considerably protracted, not only without detriment, but greatly to the advantage of the negative as regards softness and harmony of detail. The colour of the deposit given by rodinal is of a bluish-black.

All the above-named developers are used in solution, in conjunction with either an alkali or an alkaline carbonate, apart from which they can hardly be said to have any developing power at all. They all require the presence of sodium sulphite or of potassium metabisulphite to obviate staining of the film; and, if allowed to act upon the plate for a sufficient length of time, they would reduce some of the silver salt which had escaped the action of light. In the case of ferrous-oxalate, however, we have an agent of a totally different type.

This compound was first suggested as a developer for dry-plates by Carey Lea, of Philadelphia, twenty years ago. It was slow, however,

to gain popular favour in England—partly, as would appear from the difficulty of preparing it; and it is still very much in the background in comparison with the position it holds on the Continent and in America, although in both places it is giving way before late comers of the metol order. In England, however, it has been found extremely useful for bromide paper—"a purpose," says the *Year Book of Photography*, "for which it is still extensively employed, and for transparencies, and in scientific work where a clear black image is required, and where its inertness as regards an unexposed plate may be taken advantage of." Amongst its other good qualities may be named the extreme simplicity of its use, its cleanliness, and the ease with which it is worked. The energy of ferrous-oxalate as a developer is enormously augmented by the addition of a few drops of sodium hyposulphite. The negative is thereby greatly increased in strength, while the high lights of the picture appear almost at once.

Notwithstanding all these powerful rivals, it is due to pyrogallic acid—the first and, for a time, the only developer—to say that it still holds a fair position in the race, and proves itself very hard to beat. Many, indeed, prefer it to all other developers—partly, of course, because they are so used to it, but in no small degree because it possesses a very wide range of usefulness.

It need hardly, perhaps, be added that to use these and the many other substances useful for development—and every powerful absorber of oxygen, soluble in water, is such to a greater or less extent—to the best advantage, a sufficient knowledge of chemistry is essential; and anyone taking up photography as a serious study cannot

be too strongly urged to prepare himself by a thorough grounding in that useful science.

CHAPTER XV.

COLOUR PHOTOGRAPHY.

THIS little treatise would be incomplete without something about colour photography, although in reality, up to the present time, there is no such thing. Whether there ever will be is another question.

Every few months brings us some fresh announcement to the effect that at length the great problem has been solved, and that photography in colours is an accomplished fact. Possibly the reported discovery may be discussed, or at least kept before the public, for a few days; but in the end it is allowed to sink quietly into oblivion. There has not been much in it. By some faulty manipulation, colours of a kind have been produced upon collodion or on gelatine plates; or they have been the result of a dividing of the film (such things have occurred), or of a dozen other accidents. In other cases it is merely a variation of the three-colour contrivance, whereby the photograph is made transparent, and coloured on the back, or it may be that the colouration is only another form of the familiar mechanical process by which—using several photographs—the picture is printed in sections, each section receiving its separate portion of colour. These methods may be found to satisfy some, and in several the results are exceedingly fine; but the result is a col-

oured photograph, not the photograph of natural colours.

Nevertheless, something has been done in regard to colour photography—enough possibly to satisfy those who have given careful attention to the subject that the problem will one day be solved. Of the men who have gone into the matter most thoroughly, and have achieved some results, the names that stand out most prominently are those of Herschel, Becquerel, St. Victor, and Lippmann.

As early as 1810 certain observations were made by Dr. Seebeck, of Jena, which tend to encourage the view that direct colour photography is within the range of possibility. He was repeating the experiments made by Ritter in 1801 in respect to the ultra-violet rays of the solar-spectrum. To this end Seebeck passed a beam of white light through a prism, and received the spectrum upon a surface which had been rendered sensitive by means of chloride of silver, and upon which he subsequently perceived distinct traces of colour. Referring to the experiment in the "Farbenlehre" of Goethe, he says:—

"When a spectrum produced by a properly constructed prism is thrown upon moist chloride of silver paper, if the printing be continued from fifteen to twenty minutes, whilst a constant position for the spectrum is maintained by any means, I observe the following: In the violet light the chloride becomes a reddish-brown (sometimes more violet, sometimes more blue), and this colouration extends well beyond the limit of the violet. In the blue part of the spectrum the chloride takes a clear blue tint, which fades

away, becoming lighter in the green. In the yellow I usually found the chloride unaltered; sometimes, however, it had a light yellow tint. In the red, and beyond the red, it took a rose or lilac tint. This image of the spectrum shows, beyond the red and the violet, a region more or less light and uncoloured."

At a subsequent period, that is, after he had heard of the discovery of photography in 1837, Sir John Herschel was led to experiment in the same direction, and discovered that "the spectrum impressed upon a paper spread with the chloride of silver is often beautifully tinted, giving, when the sunshine has been favourable, a range of colours very nearly corresponding with the natural hues of the prismatic spectrum. The mean red ray leaves a red impression, which passes into green over the space occupied by the yellow rays. Beyond this a leaden blue is discovered." Both Daguerre and Fox-Talbot observed a reddish tinge on pictures from the effect of red objects in the landscape.

Another experimenter who tried to obtain the natural colours of objects by means of photography was Robert Hunt. These researches took place between 1840 and 1843, and the results were set forth in his work, "Researches on Light," published in 1844. They are interesting, and in some cases curious; but they led to nothing very definite beyond an expression of "the hope that we may eventually arrive at a process by which external nature may be made to impress its images on prepared surfaces in all the beauty of their native colouration."

The next man of any note to embark on the same enterprise was the French savant, Edmund

Becquerel. His method was to take a silver plate, such as was used in daguerrotype, and to prepare its surface with a thin coating of chloride of silver. This was done either by soaking it in chlorine water, or by forming a surface of silver chloride by means of hydrochloric acid and chlorine chemically treated. On a plate thus prepared an exposure of a few minutes to the spectrum was sufficient to impress the different colours.

Other experiments of a similar description were tried with equal success. But then came the crux. Like Wedgwood and Davy with their photographic prints fifty years before, Becquerel could not fix the coloured images he secured. Some he appears to have rendered more or less permanent; but the trouble was that they could only be examined in a faint light, and they would stand the air about as little as the light, oxygen speedily destroying the colours.

As we have seen, Niépce de St. Victor repeated Becquerel's experiments. He found it preferable to form his chloride of silver by immersing the plate in a solution of chloride of lime. He also shortened the period of exposure. St. Victor sent specimens of his colour-photography to the Exhibition of 1862. They included vivid reproductions of some of the chief colours; but while several of the tints remained for a few hours, others faded almost directly they were exposed to diffused light.

Poitevin, St. Florent, Captain Abney, and others experimented on the lines so ably marked out by Herschel, Hunt, Becquerel, and St. Victor, though without adding much to the volume of our acquisitions in respect to colour photography.

Poitevin, it is true, states that the colours of pictures reproduced on paper rendered sensitive by silver chloride may be fixed by means of sulphuric acid, although no one appears to have accomplished the feat.

High hopes were raised by the researches of Carey Lea in 1887; but in effect he carried us very little, if any, nearer to the goal of natural colours by photography than we were when, after patient research, Abney * gave it as his opinion that the colours obtained upon silver salts by Becquerel and others were due to the oxidation of the silver compounds themselves.

In 1891, however, a new investigator came upon the scene, and in the results obtained by Professor Gabriel Lippmann, of Paris, it must be admitted that we have a distinct advance towards actual colour photography. His method, as described by him before the Royal Photographic Society, is as follows: The film in which the photograph is taken may be made of any substance, provided it is transparent and grainless. Exposure takes place in contact with a metallic mirror. The effect of the latter, which is formed by running a layer of mercury in behind the film, is to reflect back the incident coloured rays, and thus make the incident light waves stationary. The stationary vibrations, falling in the interior of the sensitive film, impress their own structure upon it, and by virtue of the structure thus imparted, the brown deposit of silver, when viewed by reflected white light, appears imbued with the same colours as are possessed by the image in the camera.

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* "Proceedings of the Royal Society," 1897.

These colours are produced by "interference" in the same way as the hues of the soap-bubble or mother-of-pearl. That such is their origin is demonstrated by the fact that the tints of a negative change, when damped, by reason of the gelatine of the film swelling slightly, and thus altering the structure of the silver deposit.

The colours produced by his method, Professor Lippmann holds to be perfectly true if exposure and development be properly conducted. They can, moreover, be completely fixed, so as to resist the action of light and time. Development and fixing are affected in the usual way. But, although Lippmann's process is a decided advance, up to the present it has resisted all attempts to obtain prints from the negatives, and hence, so far as practical colour photography is concerned, we are much where we were.

As regards the three-colour process, it must be admitted that the results obtained are very beautiful; but, speaking in the exact language of science, they cannot be called colour-photography. In Mr. Ives's trichromic method there is something peculiarly striking. He shows in a specially contrived apparatus three negatives taken under different conditions; these he lights under glasses of three colours, with the result that the picture is seen coloured—not indeed with the truth and harmonious blending of nature, but with a very taking and almost deceptive approximation thereto. The suggested explanation is that the several parts of the negative "select" their appropriate colours. The term may mean anything or nothing; but one can see in the suggestion an adumbration of an idea. Thus, if we could imagine that the molecules of matter were in a sense crys-

tallisations, each with so many facets, and that each facet had the power of absorbing a given colour, we might arrive at a very workable theory of colouration. That is, when the molecules fall together, or agglomerate in a certain way, they would present a facet which would absorb or reflect a certain colour, and that only. If they fell together or crystallised in another way, presenting another facet, we should have another colour, and so on. But the subject is enormously difficult, and a wise investigator does not go far on the back of a theory.

CHAPTER XVI.

THE TELEGRAPH AND PHOTOGRAPHY.

EVEN while one writes, the tale of achievement in which photography plays its part takes a new if not a surprising departure; for in these days of rapid developments in science nothing greatly surprises. The new thing is quite in the line of research wherein many recent triumphs have been won, and to which much expectant thought and investigation has been turned. The transmission of drawings, and especially of photographs, by means of the telegraph, so that a person telegraphing or telephoning to a friend could at the same time transmit his "counterfeit presentment," in order, as it were, to stamp and verify his communication, has long been an end aimed at by inventors, and we have from time to time heard of partial success obtained. It is to an inventor of Cleveland, U. S. A., however, that we are in-

debted for the accomplishment of the task; and, if we may credit the report of the *Cleveland World*, the invention is a very remarkable one. Mr. Amstutz, the patentee, calls it the artograph, and according to the published accounts the instrument is exceedingly simple, and can be supplied, both

FIG. 39.—Before Sending.

the sending and the receiving apparatus, at a cost of something like seventy-five dollars a set, that is, under sixteen pounds.

Mr. Amstutz claims for his invention that it will transmit photographs as rapidly as the telegraph sends messages, and that it permits of the use of an ordinary telegraph for the purpose. The secret of the artograph lies in the discovery

—not a new one to anyone who knows aught of engraving—"that a picture, perfect in detail, may consist of absolutely nothing but parallel lines." On this principle he based his contrivance "for sending pictures by wire, the details of the picture depending on the breadth of the lines,

FIG. 40.—After Sending.

which make the lights and shades, and in that way work out the features of the portrait or other picture." The lines are extremely fine, running from forty to eighty an inch. The instrument works automatically, and may be regulated either by clock-work or by electricity.

The photograph to be transmitted may either be enamelled on a copper sheet, which is a rapid process, not taking more than five minutes, or prepared on the inventor's acrograph, or engraving machine, an invention which "relates to the art of reproducing photographs, sketches, etc.,"

for printing or other purposes. "It consists in first forming the subject to be reproduced with an uneven surface, and then causing a graver or cutter to automatically interpret, in contiguous paths of cutting, which vary in depth in proportion to the lights and shades of such relief surface, the subject upon another surface that is superimposed upon the first subject.

By this process, which is speedier than the use of the copper sheet, the recording material is made of a sheet of celluloid, or other yielding substance. Upon this a photo-gelatine sketch, or other relief surface of the subject to be reproduced, is impressed. The film-picture "is then wound on a drum and the clock-work put in motion. The feeding is automatic and as the needle passes over the variable photo surface, it will vary, break and complete the electric current. At the other end of the line, the receiving material, placed upon a cylinder like that at the sending end, interprets the variations, turning them from vertical into horizontal ones, and bringing out the lights and shades of the picture or photograph. When the lines are sufficiently coarse, the picture at the transmitting end has the appearance of being cut by vertical lines, while at the receiving end the picture appears to be composed of tiny squares, the perfection of whose detail depends on the lights and shades which go to make up the picture.

"The substance at the receiving end may be celluloid or chemically prepared paper. In case of celluloid a graver must be used in order to cut into the receiving substance. In case of chemically prepared paper the lines will be brought out by its development. Mr. Amstutz

believes that it is possible to receive on a thin copper sheet, covered with prepared chalk, known by artists as a 'chalk plate,' in which case a metal cast of the picture can be taken directly from the chalk plate, thus greatly facilitating the preparation of the photograph for the use of newspapers. Owing to the fact that celluloid will not stand the heat of stereotyping, the picture must be transferred by pressure if used for newspaper work."

Such is a brief account of the invention as it comes to us.* Possibly it may not prove to be equal to all the patentee claims for it; but it is not improbable that it may do even more. It will be seen from the above that the inventor regards the artograph as chiefly useful for newspaper portrait work, although he has his eye on the wrong-doer as well. "Suppose," says the account above drawn from, "a noted criminal escapes from the New York police. Almost as swiftly as the message recording his escape can be transmitted, a photograph of the criminal can be sent, and the police in any city in the country can be on the look-out for the criminal." Mr. Amstutz is doubtful whether his apparatus for telegraphic photography will be available for other than portrait work until further developed, owing to the sharper outline and closer detail required. But surely this alone is an achievement.

While, however, the inventor is proud of his photograph transmitter, which was invented two years ago, although only recently patented, he

* Quoted from the *British and Colonial Printer and Stationer.*

looks for the greatest profit from his engraving machine, or acrograph. The engravings produced by it on celluloid do not tarnish and are unaffected by moisture. Fire alone destroys them; hence a photograph reproduced by means of the acrograph will enjoy a sort of triple warranty of permanence.

CHAPTER XVII.

PHOTOGRAPHY AND ART.

It remains to say a few words on the all-important subject of art as connected with photography. There are those who affirm that photography is not an art, and the photographer therefore not an artist. Well, it is certainly true that every operator with the camera and the prepared plate is not an artist; but to say that photography, in its function of picture-producer, is not an art, is surely to make light of the meanings of words. There is, of a truth, no art in carrying about and manipulating an automatic view-taker, any more than there is science in heaping specimens higgledy-piggledy in a cabinet. But when certain means are carefully and deftly employed to the attainment of a given end, there is certainly art, and art of a high order, if these means are used with intelligence and taste. But therein lies the difference. Many have taken up photography thinking that in a cunning box of mechanics lay the royal road to art; but their disillusionment was speedy and thorough.

"Some years ago," says the author of a recent

magazine article, "when amateur photography was in its infancy here (*i. e.*, in the United States) as well as in other countries, a soulless corporation extensively advertised a camera which only required a button to be pressed and pictures were made. The idea soon took root that there was nothing in photography, when it merely required the pressing of a button. It was apparent that any fool could do that. And when these cameras were purchased and tried, the result convinced the owners of the fact, not only that any fool could do it, but that he was a fool a good many sizes larger for doing it. A feeling of disgust and disappointment was created, and there is little doubt but that photography was taken up by thousands and dropped again when they found out how it has been misrepresented to them. I firmly believe that many of these, had they thoroughly understood what was required to become a successful photographer, would have taken the matter up properly with the determination to master it thoroughly, and would eventually have succeeded."

That is an extreme way of putting the matter, though undoubtedly true; yet there is salvation even for a buttoner—if he has eyes to see and a heart to desire the perfect thing. For therein lies the whole of art. What the photographer needs first and foremost of all is to perceive and understand the limitations of his art. It does not afford him the wide scope and comprehensive gamut of the palette; in some respects even he is more circumscribed than the artist in black and white. He cannot to the same extent impress his character upon his work; but he can go much deeper into his subject—if he will

only patiently find out the way—than either the spectrum-wielder or the handler of monochrome merely.

His difficulties divide themselves into two departments. In the first are the technical difficulties which he will have to overcome, and which have been set forth in some detail in the foregoing pages; in the second stand the elementary laws and principles of art, which can only be learned from masters or by the diligent study of books devoted to the subject.

"The gravest difficulty which he will have to surmount, and the one in which he can least profit by outside help, will be the realisation of the fact that he is producing a monochrome rendering of a coloured subject, the training of his mind to dissociate colour from his subjects and to see their monochrome value; but unless this difficulty is surmounted, he will often be deceived by the beauty of a view which will appear entirely uninteresting when rendered in monochrome, by a process which does not even give to each colour its true value." *

This question of the true rendering of a subject in monochrome is a very important one, and as it enters very deeply into the art side of photography, it has been thought well to reserve its treatment to this portion of the work.

When referring in a previous chapter to the action of light upon the sensitive salts, it was pointed out that, while the yellow region of the spectrum is the brightest to the eye, and the blue and violet region the feeblest in luminosity, it is

* "Photography: Artistic and Scientific," by Robert Johnson and Arthur Brunel Chatwood, A. I. E. E.

nevertheless these latter rays, which in photography have the predominant effect on ordinary plates. It is manifest therefore that the resulting monochrome cannot represent the real colour values of the various parts of the object depicted. In other words, the picture obtained is not a true one.

To take an instance: In a sunset sky or a yellow flower there will probably be little or no blue, while the yellow is prevalent and very luminous. If, therefore, these two objects be photographed, first with a substance or combination most impressed by the yellow, and then with one which is more sensitive to the blue, it is evident that the former will yield a more truthful monochrome print than the latter.

In taking subjects that depend for their effect to a considerable extent upon colour, such as those above named, this lack of sensitiveness to certain colours was long greatly felt, especially as regards the reproduction of paintings, and gave rise to much speculation and experiment with a view to overcoming the defect. It was not, however, until Dr. H. W. Vogel of Berlin made, in 1873, the discovery that the addition of certain dyes, like coralline, changed the maximum of sensitiveness of the spectrum,* that a partial remedy was found. Eder and Abney, as well as others, followed up his experiments, with the result that what are known as isochromatic or orthochromatic plates, that is, plates more sensitive to the yellow and red rays, were soon available for practical work, to the undoubted improvement of representations of coloured subjects in monochrome.

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* Abney.

Without going too much into technical details, it may be stated that an ordinary plate is most sensitive to the spectrum midway between the violet and blue rays. If, however, such a plate be slightly coloured with erythrosin, one of the erosin group of dyes, the sensitiveness of the region betwixt the blue and the yellow will be intensified, the result being that the greens will be more truly rendered. If it is desired to extend the sensitiveness further towards the red another dye must be employed, such as cyanin, which in combination with erythrosin will continue the sensitiveness to the yellow, and through the orange towards the red end of the spectrum.

The action of these dyes has not been fully ascertained. Vogel designated some of them "optical sensitizers," and he explained their action by supposing that when the dyes absorbed the light some sort of secondary action takes place. Abney and other authorities, however, take exception to this theory, being rather of the opinion that an organic silver salt is formed, and that this salt may be sensitive to rays of the spectrum to which the inorganic salt is insensitive, or it may increase the sensitiveness of the inorganic salt for some particular part of the spectrum. The fact that when a plate has been immersed in a solution of the dye it may be washed until all visible trace of it has vanished without in the least reducing its sensitiveness to colour seems undoubtedly to indicate the formation of an organic silver compound.

Whether this is the right explanation or not the fact remains that the dyes render the plate sensitive to the rays they absorb.

Many other dyes besides those mentioned are

available and are being had recourse to more and more. They include malachite green, cerulean, and alizarin, which are used for sensitizing the red.

But whilst a plate's sensitiveness to various colours may thus be augmented, the original sensitiveness of the different rays of the spectrum is not eliminated; it is indeed so much greater than the sensitiveness imparted by the organic dyes that the latter would be almost completely nullified were it not possible at the same time to reduce the action of the blues. This can be effected by making exposure through a screen of yellow glass, or, in the case of a picture, by illuminating it with yellow light. If we take a water-colour drawing or a painting representing, for instance, a spring landscape, we shall see that its usually prevailing colour is green, with a large admixture of yellow. To reproduce this in monochrome with fidelity to its colour values it will be necessary to use a plate that is sensitive to the region of the spectrum between the blue and the orange, as well as to the blue itself, though the energy of the blues must be moderated. If we look at an azure sky through a piece of yellow glass it will be seen that the blue will be converted into a more or less decided green. Hence by making the exposure for the spring landscape through a yellow screen, the sensitiveness of the greens and yellows will be intensified and the action of the blue reduced, and thus a truer monochrome result.

One way of attaining this end is to allow daylight to pass through light yellow paper or glass; another is to coat the surface of the lens with a film of collodion to which a slightly yellow tinge has been communicated.

"If," says Abney,* "a landscape be taken with these dyed plates without yellow glass intervening there is very little difference between the result and that obtained on an ordinary plate, the reason being that the objects reflect a large proportion of white light, and that the blue light in this reflected light is that which is most effective. If, however, a yellow glass be placed in front of the lens, the photograph will differ considerably in appearance. The blue of the sky, for instance, in the resulting print, will be rendered a grey instead of white, whilst a white cloud will be white. The greens of the trees and grass will be more harmonious, and so will any yellow object which may be in the view."

Since the above was written, however, another experimenter has obtained results which justify him in saying that gelatine-bromide plates immersed in a solution of auromine containing a small proportion of erythrosin are sensitive to all colours, including red, and give an approximation to correct colour values without the use of a screen.†

The makers of orthochromatic plates do not usually state by what method they are prepared, nor to what colours they are specially sensitive. The photographer therefore has to work in the dark to some extent until he has found out their qualifications by experiment. Hence, when the light-wielder does not mind a little trouble, he will find not a trifling advantage in preparing his own orthochromatic plates. For such—and there are amateurs enthusiastic enough to take any amount

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* "Treatise on Photography."
† "Photography Annual," 1896.

of pains when there is a definite object to be attained—a full description of the process is given by Burton in his "Modern Photography." Some useful directions are also contained in "Photography: Artistic and Scientific"—a very interesting and highly useful work.

CHAPTER XVIII.

PHOTOGRAPHY AND ART—*continued.*

THERE was a time when the art world used to sneer at photography. They said it was going to ruin art with its crude stiff fac-similes of objects, like enough to pass for the real thing, but in truth so bald and lifeless, and moreover, in general detail, so distorted and awry as to destroy all beauty, and, in the end, to wither the taste of those who put up with its vapid and soulless mimicry. There was some truth in the charge, of course—enough to weight it, in fact, and almost to drive it home; but that was in the early days, ere the light-picturer had had time to grow. There are few who would venture to repeat the denunciation now; for, anathematised as it was by those who suffered from its coming—miniature painters in particular—it was soon found that, like the ugly duckling, it was a thing of power and of potential beauty. It came amid muttered curses and maledictions; it stayed to aid and to bless.

No one will affirm to day that photography has not benefited art, that it has not revealed truths of representation that were barely guessed at be-

fore, and that, in portraiture especially, it has helped to a lifelikeness which the artist's unaided effort could not have achieved. One may walk through the Academy and pick out the portraits that owe much of their naturalness of pose and permeating fire of expression to the camera's unwearying touch and the light-wielder's trained power of manipulation.

In such cases it is art assisting art. Not all, however, of what is called photographic art is such in truth. Even one who has not the trained hand of the artist, and only takes views by a mechanical process, must possess an educated eye, as well as much natural artistic perception, if he would produce real pictures. It is not sufficient to be able to point his camera at an object, put in his plate, and withdraw the cap. Apart from the fact that there must be choice of subject, and selection of the fittest point of view, the man who has not studied the lighting of his picture, that is, the most suitable light for the subject in hand, has not gone far on the art side of his profession.

Many persons enjoy an inherent perception of the picturesque, and will hit upon the best point of view as by a natural instinct. All the same, not the most gifted in this respect but can learn something from a careful study of the principles and rules of art; these are few and easily understood; and being as important to the one who endeavours to make a picture by the chemical action of light as to the artist, no photographer should consider himself properly furnished as regards his brain-case until he has made himself familiar with the commoner axioms of the picturesque.

Often enough the seeker after the beautiful

may come across a picture perfect to his hand; all he needs is to transfer it to his sensitized plate. But it just as frequently happens that while the view is all that could be desired, there is something wanting—a figure in the foreground or middle distance, a bit of stratified or cumulous cloud—to give a sense of life, or, as we might say, to focus the interest. When the artist feels the need of these, he supplies the deficiency. The photographers, however, cannot with brush or pencil put in such accessories as the painter can; but by combining negatives he is able to make up his picture in much the same way.

His landscape, it may be, shows a forest road; but without some sort of life he may feel that it is dull and perhaps a little motiveless. He opines that a flock of sheep would improve it, and he goes in search of one; or it may be that he has one in his repertoire of "snap shots" that will just fit the scene. Possibly all that is needed is a little "weather," which has been well called "the expression of landscape." This he adds by means of a suitable cloud-picture which his camera has given him.

On the other hand, if his subject happens to be a little sombre, he may feel that it would add to the mysteriousness of his forest road, his mountain pass, or even his ordinary moorland track, if he dropped in a figure just where the way loses itself in the gloom. By means of it he carries the light, and so the eye, deeper into the picture.

There are of course limits to the building up of a picture in this way; although at the Art Treasures Exhibition held at Manchester in 1857, a large subject was exhibited which was composed

of thirty negatives. It was entitled "The Two Ways of Life," and was the work of a Swedish artist who practised photography at Wolverhampton. The process by which it was put together was described in the *Photographic Journal* of 1858, and showed enormous skill and patience.

Although, as a *tour de force*, Rejlander's combination picture has never perhaps been approached, yet his effort was shortly after greatly outdone by the beautiful effects in combination printing produced by Mr. H. P. Robinson. The latter's method was to print each negative in turn upon the sensitized paper, the part not intended to be acted upon being obscured by opaque paper, black varnish, or some other like adjunct. The operation is described in "Silver Printing," written by Robinson in collaboration with Captain Abney, and is well worthy of careful perusal.

These way-breakers were soon followed by others, and now the making of pictures from different negatives is almost an everyday matter, the artistic results being visible at all the photographic exhibitions. Many are very beautiful and effective; but here and there one is conscious of over-elaboration, of a departure from the simplicity of nature, which is not always thinking of making a picture, and so of a tendency to incongruity. Better have a picture less "composed," and with something of the fortuitousness of the field, so to speak, in preference to anything like an approach to the incongruous.

Nature is so subtle in her "poses," if one may use the term in such a connection, as well as so simple, that it is always best, if possible, to get your picture without making up. There is no lack of material. Nature is a very prodigal in

the heaping up of her riches in this respect; and to the true artist she is ever inciting to fresh endeavour by the mystery of her *chiaroscuro* and the inimitable richness and subtle gradation of her tones.

If composition must be resorted to, it should be done sparingly and with the greatest care to keep the added figures or what-not in strict subserviency to the main point of interest. In other words, the figures must be subordinate to the landscape, or else the landscape must be sunk into subordination to the figures. Wherever portraiture of figures is attempted, the landscape must needs become of secondary importance, and fall to the level of a background merely; nothing can be allowed in it of chief interest to carry the eye away from the group.

In his "Pictorial Photography"—a book which every photographer would do well to read—Robinson says: "The figure must be *of* the subject as well as *in* it, in order that unity may be preserved," while, above all, a thing to be avoided "is the indiscriminate dragging in of figures into scenes in which they have no business, and where they do nothing but mischief."

This "dragging in" is too often done on the ground that without figures there is a lack of human interest. This is a superficial view. It does not follow that because a landscape or sea-view is destitute of figures it is therefore deprived of human interest. Sometimes the deepest human interest may lie in the picture's subtle appeal to the feeling of solitude, or to that sense of helplessness and dependence which is so pathetically human. A picture is made for the one who looks upon it, and he must bring something to the con-

templation if he would truly enjoy it. In other words, something must be left to the imagination. Hence the need of not telling too much, of not filling up every available inch of space, like the fable with its laboured moral. The lonest hut will stand for human occupation; a windmill will give life to a figureless scene. So a sail tenants with a sense of human endeavour the immeasurable deep; while a lighthouse, bidding adieu to the sun, tells of men that contend with the elements and ships that go forth or come home in the night.

The feeling for composition is a gradual acquisition; it cannot be learned all at once; to some even—though this is not often the case—it may be for ever a sealed book. The kernel of the thing must be in the mind; and if not there it is hopeless to try to cultivate it. For those who have it in them the method of development is to look continually at nature, and to compare its effects with those produced on canvas by the best painters. At first, perhaps, a feeling of despair may take possession of the tyro: he will see beauties the most striking obtained by methods the most varied, and often apparently quite contradictory; sometimes the principles applied may even appear to set nature at defiance; but gradually out of seeming diversity and confusion system and order arise, and out of apparent chance the strictest rule and reason. By this method of training the eye and feeling, much is in time perceived by one of real faculty which cannot be expressed in so many words. Sir Joshua Reynolds puts the matter very aptly in his Sixth Discourse:

"It must of necessity be," says he, "that even

works of genius, like every other effect, as they must have their cause, must likewise have their rules; it cannot be by chance that excellences are produced with any constancy or any certainty, for this is not the nature of chance; but the rules, by which men of extraordinary parts, and such as are called men of genius work, are either such as they discover by their own peculiar observations, or of such a nice texture as not easily to admit of being expressed in words; especially as artists are not very frequently skilful in that mode of communicating ideas. Unsubstantial, however, as these rules may seem, and difficult as it may be to convey them in writing, they are still seen and felt in the mind of the artist; and he works from them with as much certainty as if they were embodied, as I may say, upon paper. It is true these refined principles cannot be always palpable, like the more gross rules of art; yet it does not follow but that the mind may be put in such a train that it shall perceive, by a kind of scientific sense, that propriety which words, particularly words of unpractised writers such as we are, can but very feebly suggest."

Nor need the student, making himself familiar with the power and compass of art in this way, lose courage because he works with a circumscribed medium. Until he begins to work in light and shade, he has but little idea what powerful effects are at his command. Perhaps, in order to show him something of the power of monochrome, I cannot do better than quote a few sentences from John Burnet * (whom every photographer should study).

* "Practical Essays on Art."

"Breadth of effect," says he, "is only to be produced by a great extent of light or shade pervading the picture. If an open daylight appearance is intended, such as we see in Cuyp, etc., it will be best produced by leaving out part of the middle tint, and allowing a greater spread of light and half-light; this will also give the darks the relative force which they possess in nature. If a breadth of shadow is required, such as we find in Rembrandt, etc., the picture ought to be made up of middle tint and half dark. In the one treatment the darks ought to tell sharp and cutting, which is the characteristic of strong daylight; in the other the lights ought to appear powerful and brilliant, enveloped in masses of obscurity.

"The influence of shadow upon any composition, when carried beyond the necessary depth for the relief, or distinct marking of the several parts, is breadth, from its absorbing many of the half tints and rendering the darks less cutting; and repose, from there being fewer of the outlines visible; hence arises a certain grandeur attendant upon space, and an agreeable sensation from the spectator being allowed to exercise his own fancy in embodying indistinct forms.

"Thus the gloomy solitude of a wood is increased by the absence of the twittering light through the trees, the absence of their harsh colour, and the distinct form and crisp marking of the leaves. Rembrandt has carried this property of shadow beyond the hope of any improvement, and by this means has clothed the most trifling subject with a portion of sublimity. If we allow ourselves to be influenced by the association of ideas, it is capable of imparting a greater degree of horror to any subject of terror; as imaginary

dangers appear greater than real, being augmented by the operations of the mind. Milton has made use of this quality in describing the situation of the fallen angels:

> " 'From those flames
> No light, but rather darkness visible,
> Served only to discover sights of woe,'

and Titian in his picture of the Martyrdom of St. Laurence, which otherwise is disagreeable from its being cold and black."

A very little study, in short, will convince the thoughtful, that notwithstanding its deprivation of colour, all nature's manifold moods are at the command of the photographer, and in a way that neither pencil nor brush can emulate. Handicapped though he is in the respect that the rich gamut of colour with which nature dazzles the eye and entrances the sense is withheld from him, and that all the varied enchantments she thus produces have to be translated into monochrome, yet the light-wielder, notwithstanding these disadvantages, has a range of tonality within his grasp, and an intimacy and depth of touch that almost compensate him for the lack of a prismatic palette.

The prismatic palette may come in time; meanwhile it is for the wise worker not to quarrel with his tools, but, remembering, in the words of Shakespeare, that for him "The glorious sun stays in his course and plays the alchemist," determine to produce the best he can within the limitations of his art. No doubt those limitations are at times very provoking. Every photographer has felt them. He sees a glorious bit of nature before him, and sets his sun-magic to work. The

result is perhaps a really exquisite monochrome presentment of the scene; but, alas, when he compares it in his mind's eye with the works of a Turner or a Linnell, how far it falls short of the almost indescribable charm of landscapes by those artists or others of similar rank and genius!

The witchery of Turner's and Linnell's landscapes, and, indeed, of those of all great artists, is their feeling of warmth, serenity, and soul. But looking at most landscape photographs, we feel a total lack of warmth, there is little serenity, while as for soul—"We start, for soul is wanting there." Not a few landscapes, however, have been produced which satisfy the eye that real and even high art is not beyond the reach of photography. As regards figure photography we must speak with less assurance. The number of figure photographs that have been produced comparable with the products of the painter's hand is few; still such works have been produced, and what has been done once can of course be done again.

These exceptions are the things which the light-wielder should set before him as a source of inspiration and stimulus, and not allow himself to be discouraged by the numberless failures he sees, and his own shortcomings. It is disheartening to see a beautiful sunlit meadow come out nearly black in his picture, and an entrancing sky full of fleecy cloud and atmospheric life show as a mere bald patch of staring white. We know that a sunlit meadow is not black, and we have it on the authority of Ruskin that "white paper is not the least like air." But though these perplexing things will occur, the adept in photography knows the remedy, and all that he has acquired is at the

command of the willing learner. Hence the motto of the one who takes up this combined science and art should be, "All that there is in it or nothing." He who does that will find but little cause to complain of the limitations, in view of the almost boundless possibilities of photography. Something has been said on the subject in a preceding chapter; but I cannot do better than close my little treatise by quoting the remarks of Mr. F. H. Robinson, one of the fathers in photography, on this question of the scope of the science.

"At a first glance," said Mr. Robinson, "it may be supposed that the subjects of the photographer would have no limit. The range of the art is from the infinitely little to the infinitely remote; from the most microscopic atom to the nebulæ in unimaginable space—nay, it has gone beyond the microscope, and depicted the invisible. Shakespeare 'exhausted worlds, and then imagined new'; but even his vast realms were not wider than those open to the camera; for the photographer claims the whole universe of fact, and calls for recognition in the regions of the imagination. The unthinking goose-quill of the poet was no more, in itself, able to write than the unthinking camera of the photographer is to make pictures; but both are mighty instruments in the hands of mighty men."

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